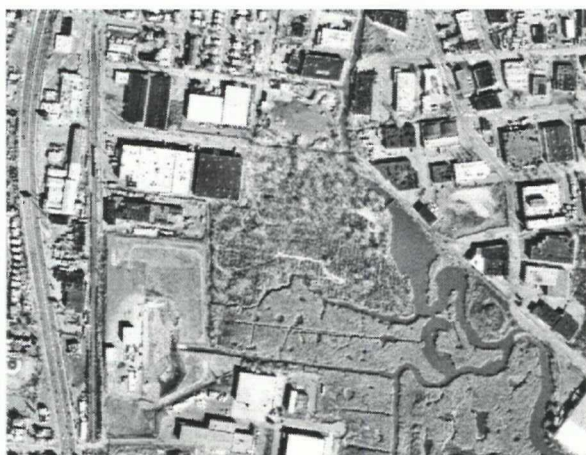


Environmental Group

Agency Review Draft

Phase I Remedial Investigation Report: Ventron/Velsicol Site, Wood-Ridge/Carlstadt, New Jersey

Volume 1 of 3



Prepared for

Velsicol Chemical Corporation
c/o Memphis Environmental Center
Memphis, Tennessee

Morton International, Inc.
Chicago, Illinois

284823





Agency Review Draft

**Phase I
Remedial Investigation Report:
Ventron/Velsicol Site,
Wood-Ridge/Carlstadt,
New Jersey**

Volume 1 of 3

Prepared for

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December 14, 1998

CERTIFICATION STATEMENT

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant civil penalties for knowingly submitting false, inaccurate, or incomplete information and that I am committing a crime of the fourth degree if I make a written false statement which I do not believe to be true. I am also aware that if I knowingly direct or authorize the violation of any statute, I am personally liable for the penalties.

For Velsicol Chemical Corporation

CH Hanson
Signature

Charles R. Hanson
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Vice President
Title

12/11/98
Date

For Morton International

Signature

Printed Name

Title

Date

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I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant civil penalties for knowingly submitting false, inaccurate, or incomplete information and that I am committing a crime of the fourth degree if I make a written false statement which I do not believe to be true. I am also aware that if I knowingly direct or authorize the violation of any statute, I am personally liable for the penalties.

For Velsicol Chemical Corporation

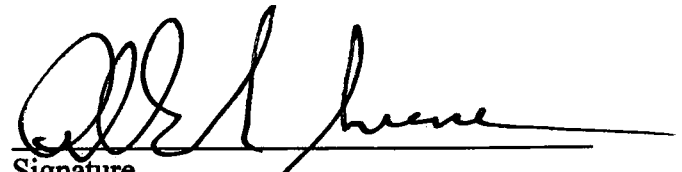
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ACRONYMS AND ABBREVIATIONS

ACOE	Army Corps of Engineers
AVID	Advanced Identification of Wetlands
BBL	Blasland Bouck & Lee
Berk	F.W. Berk and Company, Inc.
BITM	<i>Background Investigation Technical Memorandum</i>
bgs	below ground surface
BOD	biochemical oxygen demand
BPJ	best professional judgment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
COD	chemical oxygen demand
DEIS	Draft Environmental Impact Statement
ECRA	Environmental Cleanup Responsibility Act
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
HMD	Hackensack Meadowlands District
HMDC	Hackensack Meadowlands Development Commission
IDL	instrument detection limit
IVA	Indicator Value Assessment
Lpm	liters per minute
Morton	Morton International, Inc.
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NRDCSCC	Non-Residential Direct Contact Soil Cleanup Criteria (New Jersey)
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PID	photoionization detector
POTW	publicly owned treatment works
RDCSCC	Residential Direct Contact Soil Cleanup Criteria (New Jersey)
RI/FS	remedial investigation/feasibility study
SAMP	Special Area Management Plan
SoPCs	substances of potential concern
Stewart	James M. Stewart, Inc.
SVOC	semivolatile organic compound
TAL	target analyte list
TCL	target compound list
TSS	total suspended solids
Velsicol	Velsicol Chemical Corporation
Ventron	Ventron Corporation

VOC
WRCC
WET
Work Plan

volatile organic compound
Wood Ridge Chemical Corporation
Wetland Evaluation Method
Remedial Investigation/ Feasibility Study Work Plan

1.0 INTRODUCTION

On behalf of Morton International (Morton) and Velsicol Chemical Corporation (Velsicol), Exponent is conducting a remedial investigation and feasibility study (RI/FS) for the Ventron/Velsicol Site in Wood-Ridge and Carlstadt, New Jersey, as defined by the "Resolution of the Berry's Creek/Wood-Ridge Site Action Committee" (Resolution) with the New Jersey Department of Environmental Protection (NJDEP), executed on August 15, 1996. The Resolution is an amendment to the October 26, 1984 "Stipulation and Supplementary Order Approving Cooperative Agreement for Remedial Investigation and Feasibility Study and Amending Procedural Order Involving Remedy" (Stipulation). The Stipulation covers the 38-acre Ventron/Velsicol Site, including the areas of Berry's Creek potentially affected by industrial activity at the Site, while the Resolution provides for implementation of a separate RI/FS for the Ventron/Velsicol Site. The Ventron/Velsicol Site is designated as a National Priorities List (NPL) site identified by the U.S. Environmental Protection Agency (EPA) number NJD980529879, and bearing CERCLIS ID number 02C7.

This document presents the results of a remedial investigation for the Ventron/Velsicol Site (referred to in this report as the "Site"). This document was prepared in accordance with the reporting approach shown in Figure 5-2 of the *Remedial Investigation/Feasibility Study Work Plan* (Work Plan) (CRA 1996). As shown in this figure, risk assessment and feasibility study reports will be prepared later and presented in separate documents.

1.1 PURPOSE AND ORGANIZATION

The overall purpose of this remedial investigation is to develop sufficient site characterization information to support informed risk management decisions for the Site.

The risk management decisions will be supported by the subsequent risk assessment and feasibility studies.

The specific objectives of the Phase I remedial investigation were to:

- Identify substances of potential concern (SoPCs) that have been released from and are present at or adjacent to the Site
- Identify and characterize the sources of SoPCs at the Site
- Characterize the spatial distribution of SoPCs at the Site ✓
- Characterize the transport and fate in the environment of SoPCs at the Site. ✓

The major Phase I remedial investigation activities conducted to support achievement of these objectives included:

- Sampling and analysis of environmental media at the Site
- Geophysical and hydrogeological investigations
- Wetlands assessment
- Cultural resources survey
- Hazardous substance inventory.

These investigations were performed in accordance with the Work Plan (CRA 1996) approved by NJDEP on March 19, 1996. Some modifications to this plan were approved by NJDEP prior to performing the field work and are documented in the revised version of the *Field Sampling Plan* provided in Appendix A. Other modifications were needed based on the field conditions encountered. These modifications are described in Section 2.

The objectives of this remedial investigation were met through evaluation of information obtained during this remedial investigation (from the activities described above) and through comparison with results obtained in 1990–1991 during air, groundwater, and soil studies performed by NJDEP. SoPCs were identified through chemical analyses of environmental media from and adjacent to the Site and subsequent screening of the chemical analysis results against the appropriate New Jersey screening criteria. The Phase I chemical analysis, together with information derived from the hazardous substance inventory and the geophysical investigation, provided a sufficient understanding of the sources and distribution of SoPCs on Site. The transport and fate in the environment of SoPCs were characterized based on the observed concentrations in the various media, geochemical conditions at the Site, and the physical mobility of SoPCs and their potential interaction in the various environmental media. Some additional data collection recommendations to strengthen the understanding of current conditions are presented in Section 8.4. Further evaluation of transport and fate, and possibly additional data, may also be needed to support subsequent activities such as the risk assessment or feasibility study. These potential needs, however, cannot be defined at this time.

Previous investigations at the Site, other than the NJDEP studies in 1990–1991, were used to provide general background knowledge of Site conditions but were not incorporated into the data set used to meet the remedial investigation objectives. An overview of these previous investigations is presented in the *Background Investigation Technical Memorandum (BITM)* (Volume 3 of this remedial investigation report).

The purpose of this remedial investigation report is to present the Phase I Site characterization methods and results and to identify additional data, if any, needed to support the remedial investigation objectives. This report is structured in accordance with the EPA guidance for reporting on site investigations under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (U.S. EPA 1988a) and also addresses the requirements of the New Jersey Department of Environmental Protection (NJDEP) Technical Requirements for Site Remediation (NJAC 7:26E). Section 1 provides a general site description, a site history, and a summary of the SoPCs

for the Site. The remainder of this report consists of eight sections and two volumes of supporting attachments, as follows:

- *Field and Laboratory Investigations* (Section 2) describes the investigations performed as part of this remedial investigation
- *Physical Characteristics of the Site* (Section 3) provides an overview of the Site's physical characteristics based on both data collected as part of this remedial investigation and data from other sources
- *Nature and Extent of Contamination* (Section 4) describes the measured distribution of SoPCs for the Site
- *Transport and Fate of SoPCs* (Section 5) describes the transport and fate of SoPCs at the Site
- *Human Health Risk Assessment* (Section 6) will be provided later as a separate document
- *Ecological Risk Assessment* (Section 7) will be provided later as a separate document
- *Summary and Conclusions* (Section 8) summarizes key results and recommendations from this remedial investigation
- *References* (Section 9) provides a list of references cited in this document
- *Appendices A through M* in Volume 2
- The BITM in Volume 3.

1.2 SITE DESCRIPTION

The Site is located in Bergen County, New Jersey, within the boroughs of Wood-Ridge and Carlstadt. It is an irregularly shaped, 38-acre area within an industrialized area of

northeastern New Jersey. Approximately 15.7 of the 38 acres are within the Borough of Wood-Ridge, and the remaining 22.6 acres are within the Borough of Carlstadt. The entire Site is generally within the Hackensack Meadowlands area, and the portion in Carlstadt is also within the jurisdiction of the Hackensack Meadowlands Development Commission (HMDC).

The Site is bordered to the east by Berry's Creek, to the west by the Diamond Shamrock/Henkel and Randolph Products properties and Park Place East, to the south by Diamond Shamrock/Henkel ditch (south) and Nevertouch Creek, and to the north by Ethel Boulevard and a railroad track. Two active commercial/industrial facilities and an empty lot, on which a publicly owned treatment works (POTW) was formerly located, lie immediately north of Ethel Boulevard and the railroad track. The railroad crosses Berry's Creek at the northeast corner of the Site and continues south along the eastern side of Berry's Creek. Figure 1-1 shows the Site location.

Land use in the immediate vicinity of the Site is primarily commercial/industrial. Teterboro Airport is located approximately 0.6 miles to the north, State Highway 17 is approximately 500 ft to the west, and the Meadowlands Sports complex is approximately 1 mile to the south. The immediately adjacent Diamond Shamrock/Henkel property is undergoing an active remediation program under the NJDEP Environmental Cleanup Responsibility Act (ECRA). The closest residential area is approximately 750 ft to the north.

DEVELOPED AREA DEFINED
Two active warehouses, referred to as the Wolf Warehouse and the U.S. Life Warehouse, are located on the northernmost portion of the Site. The Wolf Warehouse is east of the U.S. Life Warehouse. The former mercury processing facility was located on the portion of the Site that is now occupied by these warehouses. This portion of the Site covers approximately 7 acres and will be referred to as the "developed" portion of the Site.

Highest
Hg
levels

Approximately 19 acres of land that were filled but not developed lie generally south of the developed portion of the Site. This portion of the Site is bordered to the north by the

railroad track, to the south by the Diamond Shamrock/Henkel ditch (north), and to the east by Berry's Creek. This area will be referred to as the "undeveloped filled" portion of the Site.

The remaining 12 acres of the Site, south of the undeveloped filled area, do not appear to have been filled and are generally marsh, except for a fringe of fill along the western border. There is no development within this portion of the Site, which will be referred to as the "marsh" portion of the Site.

Figure 1-2 shows the Site layout, indicating the three portions of the Site described above.

1.3 SITE HISTORY

Prior to 1927, most of the Site was marshland. From 1927 to 1974, various parties constructed and operated a mercury processing plant on the developed portion of the Site. In 1929, F.W. Berk and Company, Inc. (Berk) began operating a processing plant (Plant) and manufacturing mercury products near the current location of the Wolf Warehouse. Berk initially leased the land from the Carlstadt Development and Trading Company, but purchased the land in 1943. Between 1952 and 1955, the Magnesium Elektron Corporation (a New Jersey corporation, formerly Melberk, Inc.) leased a portion of the property that included a structure known as the Zirconium Building. Berk continued to operate the Plant until 1960, when the corporation dissolved and the Plant and property were sold to the Wood Ridge Chemical Corporation (WRCC), a wholly owned subsidiary of the Velsicol Chemical Corporation (Velsicol).

Velsicol continued to operate the Plant until 1968, when the Ventron Corporation (Ventron), a predecessor to Morton International, Inc., (Morton), purchased WRCC and the approximately 7-acre parcel on which the Plant was located from Velsicol. Velsicol retained ownership of the rest of the Site property, later transferring ownership to NWI

Land Management, Inc. Ventron operated the Plant until it was closed in 1974. In 1974, the parcel of land where the Plant was located was sold to Robert and Rita Wolf (Wolf). Wolf demolished the Plant in 1974, and in 1975, subdivided the land and transferred title of the westernmost parcel to U.S. Life Insurance Company. Two warehouses were constructed, one on each parcel.

At present, the Site is owned by three parties. Jerbil Incorporated owns the U.S. Life Warehouse property (approximately 4.2 acres). The Wolf Warehouse property (approximately 2.3 acres) is owned by Jonathan and Roni Blonde. The undeveloped filled and marsh areas (approximately 30.5 acres) are still under the ownership of NWI Land Management, Inc.

1.4 SUBSTANCES OF POTENTIAL CONCERN

SoPCs are those substances that, based on their nature and extent, merited further evaluation. This section describes the initial list of SoPCs for this Site and the process used to develop this list. The list may be further refined through the course of assessing risks associated with the Site. Sections 4 and 5 of this report focus on these SoPCs.

Mercury is the substance most clearly associated with the Plant. Other inorganic substances that may be present as a result of Plant activities include cadmium, chromium, copper, iron, lead, silver, thallium, and zinc. These inorganic substances were used at the Plant and were measured at concentrations greater than the appropriate screening criteria in at least one of the environmental media sampled at the Site. These and other SoPCs } *suggestive* may also have been contributed by sources other than industrial operations at the Site.

During the Phase I field sampling activities, samples collected from Site media were analyzed for a wide range of substances as specified in the Work Plan (CRA 1996). In the SoPC identification process, this complete analyte list was initially reduced to 35 substances that exceeded relevant screening criteria values available from the sources

listed below. Table 1-1 lists the criteria values for all substances that exceeded one or more criteria values. Table 1-1 does not list the impact to groundwater soil cleanup criteria (IGWSCC) values, because these values are generally much higher than the non-residential direct contact soil cleanup criteria (NRDCSCC) values, and screening against the IGWSCC criteria did not add any candidate SoPCs.

- Soil Cleanup Criteria (Last Revised 7/11/96): Non-Residential and Residential Direct Contact Soil Cleanup Criteria (Cleanup Standards for Contaminated Sites, N.J.A.C. 7:26)
- Soil Cleanup Criteria (Last Revised 7/11/96): Impact to Groundwater Soil Cleanup Criteria (Cleanup Standards for Contaminated Sites, N.J.A.C. 7:26)
- Specific Ground Water Quality Criteria (Ground Water Quality Standards [N.J.A.C. 7:9-6])
- Surface Water Quality Criteria Currently Applicable to New Jersey Surface Waters. NJDEP memo issued January 30, 1997 from Shing-Fu Hsueh, Ph.D., P.E., P.P., Chief, Standards, Assessment and Modeling Unit; Office of Environmental Planning, containing a table that extracts the more stringent criteria from 25 NJR 5569, December 6, 1993; 28 NJR 3782, August 5, 1996; Fed. Reg. Vol. 57, No. 246-60848, December 22, 1992; Fed. Reg. Vol. 60, No. 86-22228, May 4, 1995; and Fed. Reg. Vol. 60, No. 164-44120, August 24, 1995)
- Present Use of Draft 1991 NJDEP Guidance for Sediment Quality Evaluations (October 1997 update); Table 1: Freshwater Sediment Screening Guidelines (NJDEP memo issued October 24, 1997 from Barry Frasco, Ph.D., Assistant Director, Hazardous Site Science Element, Division of Publicly Funded Site Remediation, containing a table that extracts screening levels from Persaud, D., Jaagumagi, R., and Hayton, A. [1993], Guidelines for the protection and management

of aquatic sediment quality in Ontario, Ontario Ministry of the Environment, Ottawa).

Table 1-2 lists the number of criteria exceedances for each onsite SoPC, by environmental medium. The substances selected as SoPCs for the Site are highlighted in boldface type. The Site SoPCs include 12 metals, 3 volatile organic compounds (VOCs), 13 semivolatile organic compounds (SVOCs), and 2 polychlorinated biphenyl (PCB) Aroclor[®] mixtures. (The number and magnitude of exceedances were the primary factors for selecting SoPCs.) Other factors included the relative distribution and variability of the substance, and the quality of the data.) The chemical analysis results for each SoPC by environmental medium are discussed in Section 4. Complete analytical results are provided in Appendix B.

The selection of SoPCs specific to each medium is discussed in the following narrative. While the SoPC selection process was medium specific, the potential for interactions among media, where relevant, is addressed in Section 5.

For surface soils, the NRDCSCC were used in the SoPC screening process. The measured concentrations in surface soils exceeded the NRDCSCC for six metals (arsenic, copper, lead, mercury, thallium, and zinc) and six SVOCs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, bis[2-ethylhexyl]phthalate, and dibenz[a,h]anthracene). Bis[2-ethylhexyl]phthalate concentrations exceeded both the NRDCSCC and IGWSCC at two sampling locations. Ten of these 12 substances are identified as SoPCs in surface soil. Benzo[k]fluoranthene and dibenz[a,h]anthracene are not considered SoPCs in surface soil, because these substances exceeded the NRDCSCC at only one soil sample location (SS-29). 7

The NRDCSCC were also used in the SoPC screening process for subsurface soils. The NRDCSCC are not directly relevant to subsurface soils, because there is negligible potential for direct contact with these soils. Nevertheless, as a conservative approach, the NRDCSCC were applied in this screening evaluation, because there are no IGWSCC for

inorganic substances, and the NRDCSCC are generally much lower than the IGWSCC for SVOCs. One exception is fluoranthene, which exceeded the IGWSCC at sample location TP-18. One VOC (xylene) also exceeded the IGWSCC in the two subsurface soil samples collected from test pit TP-13.

All metals identified as SoPCs in surface soils also exceeded the NRDCSCC in subsurface soils. In addition, beryllium concentrations at two subsurface sample locations (TP-10 and TP-17) exceeded the NRDCSCC. These exceedances do not warrant including beryllium on the list of SoPCs, primarily because the measured values are less than half the EPA contract-required quantification limit (5 mg/kg), which is five times greater than the NRDCSCC (1 mg/kg). Therefore, reported concentrations that are well below the EPA contract-required quantification limit do not constitute a reliable indicator of an exceedance of the NRDCSCC criteria. Six SVOCs exceeded the NRDCSCC in at least one subsurface soil sample. Following the same rationale as for surface soils, however, four of these SVOCs can be eliminated from the list of SoPCs for subsurface soils. Benz[a]anthracene, benzo[k]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene all exceeded the NRDCSCC only at sample location TP-18. Therefore, six metals (arsenic, copper, lead, mercury, thallium, and zinc) and two SVOCs (benzo[a]pyrene, benzo[b]fluoranthene) were identified as SoPCs for subsurface soil.

Groundwater samples collected from the 12 monitoring wells located throughout the developed and undeveloped filled portions of the Site contained measured concentrations above the groundwater screening criteria for six metals (arsenic, iron, manganese, mercury, nickel, and sodium) and four VOCs (benzene, chlorobenzene, toluene, and xylene). Three of these metals (mercury, iron, and manganese) and three VOCs (benzene, toluene, and xylene) were identified as SoPCs for groundwater. Mercury was above the criterion in only one well sample, but it is still considered an SoPC because of its association with Site activities. Arsenic and nickel concentrations in groundwater samples were less than the criteria by factors of at least three and ten, respectively, in all samples except from monitoring well MW-6. Because the arsenic and nickel concentrations at MW-6 were less than twice the criteria values, and these elements are

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not associated with chemical manufacturing activities at the Site, arsenic and nickel were not identified as groundwater SoPCs. Sodium levels in groundwater samples exceeded the criterion at most wells. Sodium is not associated with known or suspected releases at the Site and is most likely related to natural causes. Therefore, it was not identified as a groundwater SoPC for the Site. Chlorobenzene concentrations exceeded the criterion in two well samples; however, the chlorobenzene concentration in one sample was only 1.5 times greater than the EPA contract-required detection limit, and, the reported concentration in the other sample was below the EPA contract-required detection limit. Benzene, toluene, and xylene are identified as SoPCs because they exceeded the criteria in one or two well samples and also exceeded the criteria during well sampling by NJDEP (NJDEP 1993a). Therefore, three metals (mercury, iron, and manganese) and three VOCs (benzene, toluene, and xylene) were identified as SoPCs for groundwater.

Filtered seep samples collected from the banks of the Diamond Shamrock/Henkel ditch (north) and Berry's Creek had measured concentrations above the groundwater screening criteria for four metals (cadmium, iron, manganese, and sodium). During sample collection, large amounts of suspended solids were introduced to the samples, so it is not appropriate to compare analytical results from the unfiltered samples to groundwater screening criteria values. Sodium levels in seep samples exceeded the criterion, but for the same reasons described above for groundwater, it was not identified as an SoPC for the Site. Mercury was identified as an SoPC because of its association with Site activities. Therefore, four metals (mercury, cadmium, iron, and manganese) were identified as SoPCs for seeps.

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produce?

Sediment samples collected from the onsite basin, the Diamond Shamrock/Henkel ditch (north), and Berry's Creek had measured concentrations above the freshwater sediment screening criteria for 23 substances. Of these, 22 are identified as SoPCs. Fluorene is excluded as an SoPC because the concentration of fluorene exceeded the screening criterion at just one sediment sample location. In addition, fluorene was not measured at concentrations above screening criteria in any other medium sampled at the Site. Therefore, nine metals (mercury, arsenic, cadmium, chromium, copper, lead, nickel,

silver, and zinc), eleven SVOCs (anthracene, benz[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, benzo[k]fluoranthene, bis[2-ethylhexyl]phthalate, chrysene, dibenz[a,h]anthracene, fluoranthene, indeno[1,2,3-cd]pyrene, phenanthrene, and pyrene), and two Aroclor[®] PCB mixtures (1248 and 1260) were identified as SoPCs for sediment.

Filtered surface-water samples collected from locations in the onsite basin, the Diamond Shamrock/Henkel ditch (north), and Berry's Creek contained measured concentrations above the New Jersey surface-water quality criteria (chronic, freshwater) for mercury, lead, and zinc. Of these, mercury and zinc were identified as SoPCs. Concentrations from filtered samples were used in the screening evaluation, because the surface-water quality criteria are expressed for lead and zinc in the dissolved phase. The criterion for mercury is expressed as the total recoverable concentration. The criterion for mercury is less than the EPA contract-required quantification limit for the chemical analysis method used in this Phase I investigation. Therefore, any mercury concentrations above this limit or the laboratory-derived IDL also exceed the criterion. Lead was not identified as an SoPC because the one dissolved concentration that exceeded the screening criterion was greater than the total concentration and therefore was not a reliable measurement.

out-of-property boundaries
A total of 23 offsite surface soil samples were collected and analyzed for a site-specific offsite soils chemical indicator list. This list was developed by comparing the onsite surface soil analytical results with the New Jersey Residential Direct Contact Soil Cleanup Criteria (RDCSCC). These more restrictive criteria were used only for the purposes of delineating the nature and extent of the contamination at these offsite locations, and for selecting the offsite SoPCs. Based on comparison with the RDCSCC and consideration of the spatial distribution of onsite exceedances, two metals (cadmium and mercury) and six SVOCs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) were identified as SoPCs for offsite surface soils.

2.0 FIELD AND LABORATORY INVESTIGATIONS

The Phase I RI field investigation was conducted in the fall of 1997 and spring of 1998.

The investigation consisted of ten components:

- Onsite and offsite surface soils investigation
- Subsurface soils investigation
- Hydrogeological investigation
- Leachate/seep sampling
- Surface water and sediment investigation
- Wetlands investigation
- Air sampling
- Hazardous substance inventory
- Topographic and location survey
- Cultural resources investigation.

This field sampling program was intended to characterize the current Site conditions, and to identify and evaluate SoPCs in the various media of concern. The Phase I remedial investigation data set was supplemented by data collected during previous investigations at the Site. The investigation was performed in accordance with the approved Work Plan (CRA 1996), as amended.

Field investigation activities were performed by Exponent or by subcontractors working under the direction of Exponent. Land N Sea Environmental Services, Inc. conducted the initial Site clearing activities and the test-pit excavations (Section 2.2.2). James M. Stewart, Inc. (Stewart) provided a range of topographic and location surveying services

(Section 2.9). Cultural Resources Consulting Group conducted the cultural resources investigation (Section 2.10). Shisler Environmental Consultants conducted the wetlands investigation (Section 2.6). The hazardous substance inventory (Section 2.8) and the geophysical (Section 2.2.1) and hydrogeological investigations (Section 2.3) were all performed by Blasland, Bouck & Lee, Inc. (BBL). BBL also collected the onsite and offsite surface soil samples (Section 2.1), the subsurface soil samples (Section 2.2.3), the groundwater samples (Section 2.3.3), and the first round of air samples (Section 2.7). Laboratory analyses were conducted primarily by Severn Trent Services (formerly AEN Laboratories), with some additional analyses performed by CEBAM Analytical (methylmercury) and Frontier Geosciences (particulate and gaseous mercury). Quality assurance review of the analytical results was performed by QA/QC Solutions.

Before the field investigation and sample collection began, Site clearance and baseline surveying were performed. Site clearance was performed on September 29 and 30, 1997, removing brush and trees to allow vehicle access to the undeveloped filled area. Access roads began at the Site entrance gate at Ethel Boulevard. One road extended along the southwestern Site boundary adjacent to the Randolph Products and Diamond Shamrock/Henkel properties, ending in a turnaround at the Diamond Shamrock/Henkel ditch (north). A second access road crossed the undeveloped filled area in a southeasterly direction, ending in a turnaround near Berry's Creek. The brush and trees removed from the access roads were chipped and left on Site. The clearing did not include any soil disturbance or addition of roadbed material to the Site.

A decontamination pad was constructed near the Site entrance gate. The pad consisted of a polyethylene liner over a bed of sand which provided a uniform surface beneath the liner and protected it from punctures or tears. The sides of the decontamination pad were bermed to prevent runoff of decontamination fluids. For the duration of the Site investigation, all equipment decontamination was conducted in this area. Decontamination fluids collected in the liner were transferred to a U.S. Department of Transportation-approved steel 55-gal drum.

A boundary survey of the Site was conducted in October 1997. In addition, a 100×100-ft control grid was established. Figure 2-1 shows the location of this grid. These and additional surveying activities are described in Section 2.9, *Topographic and Location Survey*.

Standard operating procedures were adhered to in the collection of all samples. These procedures, including the decontamination of all sampling equipment, are outlined in the revised field sampling plan (FSP) (see Appendix A). Pre-cleaned and appropriately preserved sample containers were provided by the analytical laboratory. All samples were clearly labeled and stored on ice in a cooler until they were retrieved at the Site by a representative of the analytical laboratory. Samples collected for methylmercury and atmospheric mercury analysis were shipped to the designated laboratories by overnight delivery service. All samples were maintained under full chain-of-custody procedures at all times. Field procedures and observations were recorded in bound field notebooks.

The following subsections briefly describe the Phase I field and laboratory investigations. More detailed information on procedures can be found in the revised FSP (Appendix A). For each of the ten components of the field and laboratory investigations, the following subsections describe the objectives for the collection of data, the approach, and deviations from the Work Plan (CRA 1996). All sample locations are depicted in Figure 2-1. The NJDEP approved several modifications to the original Work Plan and FSP (CRA 1996) before beginning the field program. These modifications are included in the revised version of the FSP (Appendix A) and are summarized here.

- Methylmercury was analyzed in 28, rather than all 52 onsite surface soil samples collected (Section 2.1.1)
- Geophysical anomalies were measured using an electromagnetic induction instrument instead of a magnetometer (Section 2.2.1)
- Methylmercury was analyzed in 7, rather than all 38 subsurface soil samples collected from the test pits (Section 2.2.3)

- A low-flow sampling method was used to collect groundwater samples (Section 2.3.3)
- Two additional surface water and surface sediment (Section 2.5) samples were collected in the onsite basin
- Seep (Section 2.4) and surface water (Section 2.5) samples designated for dissolved target analyte list (TAL) metals analyses were filtered in the laboratory rather than in the field
- Seep (Section 2.4) and filtered and unfiltered surface water (Section 2.5) samples were analyzed for methylmercury
- Air sampling was carried out in accordance with methods developed specifically for the collection of atmospheric mercury (Section 2.7).

Activities performed in accordance with these modifications are not considered deviations from the Work Plan (CRA 1996). Table 2-1 presents a summary of laboratory analyses conducted for each field sampling component. References to the Work Plan in the following sections refer to the Remedial Investigation/Feasibility Study (RI/FS) Work Plan prepared by CRA (1996).

2.1 SURFACE SOIL INVESTIGATION

2.1.1 Onsite Surface Soils

2.1.1.1 Objectives

The objectives of this investigation were to determine the distribution of SoPCs in shallow soil, and based on the results of the onsite soil data, to develop a list of targeted substances for analysis of samples collected during the offsite surface soil investigation

(see Section 2.1.2). Results of the surface soil chemical analyses are provided in Appendix B, Table B-1. The onsite surface soil investigation was conducted from October 23 through November 6, 1997.

2.1.1.2 Approach

Surface soil samples were obtained from 0–2 ft below ground surface (bgs) at 200-ft intervals on the control grid. However, due to physical obstructions at certain locations, samples could not be taken in exact accordance with the grid. The field team conducted a Site walk with Mr. Stephen MacGregor of the NJDEP on October 14, 1997 to review the soil sampling locations. With approval from Mr. MacGregor, five locations within the developed area and three locations within the undeveloped filled area were adjusted because of surficial obstructions. Additionally, eleven of the grid locations in the marsh area fell in Berry's Creek or the Diamond Shamrock/Henkel ditch (south). These locations were moved to the nearest non-inundated point on the Site. The actual positions of all sample locations are illustrated in Figure 2-1.

Samples were collected with a 2-ft-long, 3-in.-diameter split-spoon sampler. In the developed area and the undeveloped filled area, split-spoon samplers were driven using a compressed-air-powered jackhammer. Where the surface was covered with asphalt pavement, a compressed-air-powered jackhammer was used to remove the pavement before driving the split spoon. In the marsh area, split-spoon samplers were advanced manually using a sledge hammer.

Contents of the split-spoon sampler were visually inspected and screened with a Hnu Model P-101 photoionization detector (PID) with an 11.7-electron-volt lamp. The 0.5-ft interval that exhibited the highest field screening readings was collected and subsequently analyzed for Target Compound List (TCL) volatile organic compounds (VOCs). If no elevated readings were observed, the interval from 1.5 to 2.0 ft bgs was sampled for VOCs. The remainder of the soil material was homogenized and sampled

for the remaining analytes. After sampling, boreholes were backfilled with the unused contents of the split-spoon sampler. Locations in the developed area where samples were taken beneath the asphalt pavement were also backfilled and covered with an asphalt patch. Soil sampling logs, with physical descriptions and PID readings for each sample, are provided in Appendix C. Surface soil was collected from 52 onsite locations (SS-01 through SS-52) and are shown on Figure 2-1.

2.1.1.3 Deviations From the Work Plan

No significant deviations from the Work Plan occurred during the onsite surface soil investigation.

2.1.2 Offsite Surface Soils

2.1.2.1 Objective

The objective of the offsite surface soil investigation was to characterize the distribution of Site SoPCs on adjacent properties to the north of the Site. The Site-specific indicator chemical list was developed based on the results from the onsite surface soil samples. This list was submitted to NJDEP in an April 2, 1998 letter from Exponent to Gwen Zervas, and the list was subsequently approved by NJDEP on April 23, 1998. Targeted analytes for the offsite soils included seven SVOCs and seven metals (see Table 2-1 for the list of target analytes). Results of the offsite surface soil chemical analyses are provided in Appendix B, Table B-2. Offsite surface soil samples were collected on May 6 and 7, 1998.

2.1.2.2 Approach

Offsite surface soil samples were collected from 0–6 in. bgs. A new control grid with 200-ft intervals in the offsite sampling area was established during sample collection. Several locations were shifted away from the grid due to the presence of physical obstructions, such as railroad tracks, buildings, and underground utilities.

Samples were collected using a 2-ft split-spoon sampler or a stainless-steel hand auger, depending on ground surface and soil type. Where appropriate, samples were obtained directly from the soil surface. If present, surface cover material such as pavement, gravel, grass, or other fill material was removed using a compressed-air-powered jack hammer or a shovel, as appropriate, to expose the surface of the native soil. Samples were collected from the 0- to 6-in. interval below surface cover material. After sampling, boreholes were backfilled with the leftover sample material. Locations where samples were taken beneath the asphalt were subsequently covered with an asphalt patch. Surface soil was collected from 22 offsite locations (SS-53 through SS-74) and are shown in Figure 2-1.

2.1.2.3 Deviations From the Work Plan

Sample locations were not surveyed prior to sampling. In response to this situation, sample locations were estimated in a manner that preserved approximately uniform coverage of the planned sampling area and the planned number of samples. Sample locations were marked clearly and subsequently surveyed. The actual positions of all offsite soil locations are depicted in Figure 2-1.

2.2 SUBSURFACE SOIL INVESTIGATION

2.2.1 Geophysical Survey

2.2.1.1 Objective

The objective of the geophysical survey was to identify geophysical anomalies in the filled area of the Site where buried metallic objects (such as drums) could potentially be located. The results of the survey, combined with information about past Site activities, as described in the BITM (Volume 3), were used to select locations for test pits to verify the presence of any buried metallic objects. The geophysical survey methods and results were fully documented in the report entitled *Geophysical Investigation Report, Ventron/Velsicol (Wood-Ridge) NPL Site, Wood-Ridge, New Jersey* (BBL 1998), which was submitted to the NJDEP in January 1998. The following is a brief summary of the geophysical survey procedures. The geophysical survey was conducted from October 13 through October 22, 1997.

2.2.1.2 Approach

Electromagnetic induction data were acquired using an EM-31 Terrain Conductance Meter (EM-31) manufactured by Geonics, Ltd. Data were collected in the undeveloped filled area of the Site at 25-ft intervals on the 100×100-ft control grid. At each 25-ft interval, the in-phase and quadrature components of the electromagnetic field, described below, were recorded.

- The *in-phase component* measurements represent the ratio of the magnetic field induced by the EM-31 to the primary (site-related) magnetic field, reported in parts per thousand. These data provide a relative measure of the presence of buried metallic objects.

- The *quadrature component* is the apparent ground conductivity (terrain conductance) in millisiemens per meter. The quadrature data indicate areas of higher conductance compared to surrounding areas.

For each component, data were collected in both the vertical and horizontal dipole modes. The vertical mode measures to a depth of 6 m bgs. The horizontal mode measures to a depth of approximately 3 m bgs. The horizontal mode data were collected as a matter of routine, but did not satisfy the survey objectives of detecting potential buried material throughout the entire filled interval at the Site, and so were not used in data interpretation.

When data acquisition was complete, the field measurements were entered into an electronic spreadsheet, and then imported into the Geosoft® program to create contour maps using the contouring algorithm in Geosoft®. These contour maps are included in the *Geophysical Investigation Report* (BBL 1998). The contour maps were used to identify anomalies in the vertical dipole mode in-phase measurements and the vertical dipole mode quadrature readings.

The *Geophysical Investigation Report* (BBL 1998) proposed 18 locations for test pits. In a letter dated February 11, 1998 to Mr. Norman D. Kennel, NJDEP requested two additional test-pit locations, which were subsequently added to the test-pit program. The excavation of these test pits is discussed in Section 2.2.2.

2.2.1.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during the geophysical survey.

2.2.2 Test Pits

2.2.2.1 Objectives

The objectives of the test-pit excavation program were to evaluate the potential presence of buried metallic material at the geophysical anomalies identified during the geophysical survey, to obtain subsurface soil samples from the locations of the anomalies (see Section 2.2.3), and to obtain information to support the hazardous substance inventory (see Section 2.8). The test pits were excavated from March 16 through March 18, 1998.

2.2.2.2 Approach

Test pits were excavated using a tracked excavator. A steel plate was welded across the teeth on the excavator bucket to minimize the possibility of damaging any buried containers. A field team observed and directed the excavation activities, monitored air quality for gaseous mercury and organic vapor, and collected samples of soil and other materials. Each test-pit excavation was documented with photographs and observations recorded in a field notebook. These observations are provided in test-pit logs (Appendix D). [Photographic documentation can be made available on request.]

Each test pit was located near one or more geophysical anomalies identified during the geophysical survey (see Section 2.2.1). To minimize the possibility of damaging buried containers located near the center of each anomaly, excavation began approximately 15 ft from the center of the anomaly, and extended toward the anomaly. Soil was excavated in 1-ft lifts. The excavated soil was placed on polyethylene sheeting adjacent to the test pit. Each test pit reached to the water table, native soil, or 10 ft bgs, whichever was shallower. Soil sampling conducted during test-pit excavation is described in Section 2.2.3 of this report. Observations for the hazardous substance inventory (see Section 2.8) were also made at this time.

When observations and sampling at each test pit were complete, the test pit was backfilled with the excavated material to within 1 ft of the ground surface. The remainder of the test pit was filled with clean, imported sand. Any compromised or leaking containers encountered during test-pit excavation were removed, sampled, overpacked, and staged in the temporary drum staging area located near the decontamination pad. The excavation equipment was decontaminated by steam cleaning at the onsite decontamination pad at the completion of test pit excavation activities. The locations of all 20 test pits were subsequently surveyed (TP-01 through TP-20) and are shown on Figure 2-1.

2.2.2.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during excavation of the test pits.

2.2.3 Soil Sample Collection and Analysis

2.2.3.1 Objective

The objective of the subsurface soil sampling program was to determine the distribution of SoPCs in subsurface soil in areas potentially associated with buried materials. The results of this subsurface investigation are provided in Appendix B, Tables B-3 and B-4. Subsurface soil samples were collected in conjunction with the test-pit excavations from March 16 to March 18, 1998.

2.2.3.2 Approach

Soil samples were obtained from approximately 0–2 ft and 2–4 ft above the base of each test pit. In addition, nine discretionary samples were collected from areas of visible

contamination. To collect sample material, the excavator bucket was used to scrape the walls of the test pit at the selected depth. Samples intended for TCL VOC analysis were collected by placing soil (or other material) from the excavator bucket directly into sample jars, and avoiding any soil that had contacted the bucket itself. Samples intended for all other analyses were collected by transferring soil from the excavator bucket, avoiding any soil that had contacted the bucket itself, into a stainless steel bowl for homogenization and transfer to sample jars. Two subsurface soil samples were collected from 18 of the 20 test pits. Only one subsurface soil sample was collected from each of two test pits that were very shallow (less than 3 ft). A total of 38 subsurface soil samples and 9 discretionary samples were collected.

2.2.3.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during subsurface soil sampling.

2.3 HYDROGEOLOGICAL INVESTIGATION

2.3.1 Groundwater Surface Elevation Measurements

2.3.1.1 Objectives

The objectives of this task were to determine the groundwater surface elevation and flow direction, and to assess the effect of tidal water-level changes in Berry's Creek on Site groundwater surface elevation and flow direction. The hydrogeological investigation was performed in stages beginning on October 15, 1997 and intermittently through January 16, 1998.

2.3.1.2 Approach

The major elements of this task were surveying the locations and elevations of the 12 existing monitoring wells and three existing piezometers; redeveloping the wells and piezometers; conducting three rounds of synoptic water-level measurements; and conducting a tidal fluctuation study. The surveying and elevation measurements were recorded by Stewart as indicated in Section 2.9. The monitoring well locations (MW-1 through MW-12) are shown on Figure 2-1. Each of the other elements is described below.

2.3.1.3 Well Redevelopment

Monitoring wells and piezometers, except MW-4, were redeveloped from October 15 through October 17, 1997. Monitoring well MW-4 was not located during the initial redevelopment activities because of the dense overgrowth in this area of the Site. It was subsequently located and redeveloped on November 11, 1997.

Prior to redevelopment, the well casings were inspected, and the air in the well casing was monitored with a PID and a Jerome mercury meter. The depth to water and the depth to the bottom of each well were measured with an oil/water interface probe. A permanent mark was established on the inner well casings as a reference for depth-to-water measurements, if no mark was present.

During redevelopment, the pH, specific conductance, and temperature of the redevelopment water were measured. Redevelopment continued for 4 hours, or until the pH, specific conductance, and temperature had stabilized within 5 percent for three consecutive readings. The redevelopment water from wells MW-1 through MW-7 and MW-12, located in the undeveloped filled area of the Site, was discharged onto the ground surface in the vicinity of each well. The redevelopment water from wells MW-8

through MW-11, located in the developed area of the Site, was collected in drums and subsequently discharged to the ground surface in the undeveloped filled area.

2.3.1.4 Groundwater-Level Measurements

Synoptic rounds of water-level measurements were made on the following dates: October 15, 1997; December 9, 1997; and January 15, 1998. Each round of water-level measurements included all onsite monitoring wells and Berry's Creek upstream (north) and downstream (south) of the tide gate. Depth-to-water measurements were made with an electronic water-level indicator from the reference points on the inner casing of each well. At Berry's Creek, the measurements were made from the surveyed reference point on the deck of the tide gate. Water levels were measured to an accuracy of 0.01 ft. Prior to each use, the bottom 3 ft of the water-level indicator was rinsed with acetone and distilled water.

2.3.1.5 Tidal Study

The tidal study was conducted from January 14 through January 16, 1998. Monitoring wells MW-1, MW-2, MW-4, MW-6, MW-7, and MW-12, and Berry's Creek upstream and downstream of the tide gate were included in the tidal study. Troll™ combined data loggers and pressure transducers, manufactured by In Situ, Inc., were installed in each well. Water-level measurements were recorded by the Trolls™ at 15-minute intervals to an accuracy of 0.001 ft.

During the tidal study, an electronic water-level indicator was used to make water-level measurements of Berry's Creek above and below the tide gate from the surveyed reference point on the tide gate. The electronic water-level indicator was also used to measure the depth to water at least two times per day in the monitoring wells as a check on the data recorded by the Trolls™. The time and water-level data stored in the Trolls™

were downloaded for subsequent interpretation. The complete data set is provided in Appendix E.

2.3.1.6 Deviations from the Work Plan

Each well was pumped using a decontaminated submersible pump. To maintain the integrity of the pump's material, the acetone and nitric acid rinses were excluded from the standard decontamination procedure, as described in the revised FSP (Appendix A).

Water-level measurements were not made continuously over three tidal cycles at two locations in Berry's Creek as stated in the FSP. The electronic water-level indicators were suspended from the tide gate and could not be left unattended. Water-level measurements in Berry's Creek were made over the course of three days when field staff were on site.

2.3.2 Aquifer Parameter Tests

2.3.2.1 Objective

The objective of the aquifer tests was to determine the hydraulic conductivity of the materials immediately adjacent to each onsite monitoring well and thus provide approximate values across the Site. The results of this investigation are presented in Section 3.6, *Groundwater Hydrogeology*. These tests were conducted on January 15, 16, and 19, 1997.

2.3.2.2 Approach

Rising-head slug tests were completed at each onsite monitoring well in accordance with the method of Bouwer and Rice (1976). An 8-ft-long, 1-in.-diameter slug was used for the tests. The slug was introduced into each well, and the water level was allowed to equilibrate. The change in the water levels in the wells in response to the removal of the slug (a rising-head test) was measured with a pressure transducer immediately after removing the slug, and was recorded at logarithmic time intervals by a HermitTM electronic data logger manufactured by In Situ, Inc. Two rising-head tests were completed at each monitoring well except MW-6, as discussed below. The time and head measurements were downloaded and analyzed using the Bouwer and Rice (1976) solution for hydraulic conductivity in an unconfined aquifer with the Aqtesolv[®] (Duffield 1996) software package.

2.3.2.3 Deviations from the Work Plan

The water-level recovery time in well MW-6 was more than 90 minutes. It was determined that one measurement would provide an accurate estimate of the hydraulic conductivity at this location, because any minor difference in the recovery time would not be significant.

2.3.3 Sample Collection and Analysis

2.3.3.1 Objective

The objective of groundwater sampling and analysis was to determine the distribution and concentration of SoPCs in Site groundwater. Results of the groundwater chemical analysis are provided in Appendix B, Table B-5. Groundwater sampling was performed from November 10 through November 17, and on November 25, 1997.

2.3.3.2 Approach

Groundwater samples were collected at all monitoring wells using the low-flow purging and sampling method. Sampling occurred at least two weeks after redevelopment of these wells. Water quality parameters were measured during well purging, before sampling, and after sampling. These measurements are provided in Appendix F. When purging was complete, groundwater samples were collected directly into laboratory-prepared bottles. Samples intended for analysis of methylmercury and TAL metals (which includes mercury) were collected using an ultra-clean technique to minimize contamination, as described in the revised FSP (Appendix A).

One set of samples was collected from each monitoring well, for a total of 12 sets of groundwater samples. The well locations (MW-1 through MW-12) are annotated on Figure 2-1.

2.3.3.3 Deviations from the Work Plan

No significant deviations to the Work Plan occurred during groundwater sampling.

2.4 LEACHATE/SEEP SAMPLING

2.4.1 Objective

The objective of the leachate/seep sampling was to assess the transport of SoPCs from the Site via drainage from stream banks into adjacent streams. The stream banks are exposed and the seeps are accessible during low tide. The seeps likely consist of a blend of groundwater and surface water that has infiltrated the stream banks during high tide. The

analytical results are provided in Appendix B, Table B-6. The leachate/seeps investigation was conducted on October 15–16, 1997.

2.4.2 Approach

Field reconnaissance identified the presence of numerous small seeps along the banks of the undeveloped portion of the Site. Five seep locations were selected: three in Berry's Creek, and two in the Diamond Shamrock/Henkel ditch (north). Seeps were identified by visual inspection of the banks and subsequent confirmation that water was not originating from a muskrat's burrow. Each seep was sampled at low tide by collecting the water directly into the sampling containers. In some circumstances where the slope of the bank was fairly shallow, a small sump was constructed beneath the seep, allowing the water to accumulate and thereby assist with the transfer of seep water into sample containers. The locations of the five seep samples (SE-01 through SE-06) are shown on Figure 2-1. (Results for sample location SE-04 are the average of duplicate samples SE-04 and SE-05. Thus, no sample location exists for SE-05.)

2.4.3 Deviations from the Work Plan

The Work Plan states that NJDEP will identify the appropriate locations for leachate/seep sampling. Staff from NJDEP selected one seep location in the Diamond Shamrock/Henkel ditch (north); the other four seep locations were selected by field staff with approval from NJDEP. The incoming tide disrupted the sampling at locations SE-04 and SE-06. Sampling at these locations continued on the following day during low tide.

2.5 SURFACE-WATER AND SEDIMENT INVESTIGATION

2.5.1 Objectives

The objective of the surface-water investigation was to determine the distribution of SoPCs in surface water from water bodies in and surrounding the Site, and the variability of these substances during three tidal stages in Berry's Creek. Results of the surface-water chemical analyses are provided in Appendix B, Table B-7. Surface-water sampling was conducted on October 31, 1997 and November 12, 1997.

The objective of the surface sediment investigation was to determine the distribution of SoPCs in the upper 15 cm of the sediment, and the total mercury concentrations in the upper 2 cm of sediment. Results of the sediment chemical analyses are provided in Appendix B, Table B-8. Sediment samples from the onsite basin were collected on November 5, 1998. Sediment samples from Berry's Creek and the Diamond Shamrock/Henkel ditch (north) were collected on five days between October 30 and November 12, 1998.

2.5.2 Approach

Surface-water samples were collected by submerging individual sample containers (approximately 10 cm below the water surface) and allowing them to fill. Care was taken not to disturb the surface sediment beneath the surface water, to limit the amount of solids collected in the sample. Surface-water collection for mercury and methylmercury analysis was performed using the ultra-clean technique described in the revised FSP (Appendix A).

The upper 15 cm of sediment was collected using either an Ekman grab sampler or a stainless-steel spoon, when low tide allowed direct access to the surface sediment. Additionally, the top 2 cm of sediment was collected from a second grab sample for

analysis of mercury only. Descriptions of each sediment sample and the sampling conditions can be found in Appendix G.

Surface-water and sediment samples were collected at a total of nine sample locations (see Figure 2-1). Two locations were in the onsite basin: one at the west edge and the other at the east edge. The other onsite locations were in the Diamond Shamrock/Henkel ditch (north) at three locations spaced approximately evenly along the ditch. Surface water and sediment were collected from four locations in Berry's Creek: 1) just upstream of the railroad bridge at the northeast corner of the Site, 2) upstream of the tide gate, 3) half-way between the tide gate and the confluence with the Diamond Shamrock/Henkel ditch (north), and 4) upstream of the confluence with Nevertouch Creek. Each of the four locations in Berry's Creek was sampled at high, mid, and low tide during a single ebb tide. A total of 17 surface-water samples and 9 surface sediment samples were collected at 9 sample locations (SW-01 through SW-09 and SD-01 through SD-09) shown on Figure 2-1.

2.5.3 Deviations from the Work Plan

Surface-water collection for all three tidal stages at SW-04 occurred on November 12, twelve days after the other three upstream Berry's Creek locations. On the initial sampling attempt, the high and mid-tide samples were inadvertently collected in Nevertouch Creek, rather than in Berry's Creek. During high tide, the whole area was flooded, and the features on the map used to locate the sample location were not apparent. The navigational error was realized during sampling at low tide.

The Work Plan states that sediment collection is to be performed using a core sampler and that all sediment should be collected on one occasion during the three surface-water sampling events (i.e., high, mid, or low tide). Sediment collection was performed using an Ekman grab sampler, rather than a core sampler, due to sample volume requirements. Field personnel determined that sediment collection during a single tidal period was not

only infeasible due to time restrictions, it also did not follow sound sampling protocols. Sediment sampling causes significant disturbance to, and resuspension of, the surface sediment. Therefore, it was not appropriate to collect water samples at the same time as sediment samples.

2.6 WETLANDS INVESTIGATION

2.6.1 Objectives

The objectives of the survey were to delineate and describe the wetlands contained on the Site. The initial survey for the wetlands investigation was conducted on May 22, 1997 by Shisler Environmental Consultants, Inc. The complete report from the wetlands investigation has been provided by Shisler Environmental Consultants under separate cover (*Wetland Delineation Report*, Shisler 1997). The results of the investigation have been reviewed and jurisdictional acreage confirmed by the U.S. Army Corps of Engineers (ACOE), New York District.

2.6.2 Approach

Wetlands are defined as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Wetlands generally include "swamps, marshes, bogs, and similar areas" (40 CFR § 122.2). Wetlands on the Site were delineated through visual inspection using the multi-parameter approach: hydric soils, hydrophytic vegetation, and wetland hydrology. Wetlands were classified according to Section 404 of the Rivers and Harbor Act of 1899 and Section 10 of the Clean Water Act.

During the Site inspection, vegetation and topography were examined to identify changes that would indicate the potential presence of wetlands. Soil borings were performed to confirm the presence of hydric soils if vegetation and hydrology suggested wetland conditions. The wetland boundary was flagged at 75- to 100-ft intervals, and these flags were subsequently surveyed and plotted on a topographic Site map (See Plate 15 from Shisler 1997).

2.6.3 Deviations from the Work Plan

No deviations to the Work Plan occurred. Review of the jurisdictional wetlands by the ACOE on June 22, 1998 resulted in additional classification of Section 10 wetland acreage between the warehouses on the developed portion of the Site.

2.7 AIR SAMPLING

2.7.1 Objective

The objective of the air sampling was to determine the concentration of gaseous and particulate mercury in ambient air at the Site. The results of air sampling are provided in Appendix B, Table B-9. The first round of air sampling was performed prior to the initiation of field activities (September 4 and October 14, 1997). Although not required by the Work Plan (CRA 1996), a second round of air sampling, for gaseous mercury only, was performed during the test-pit excavations (March 16-18, 1998).

2.7.2 Approach

During the first round of air sampling, ambient, 8-hour air samples were collected at four locations in the developed area of the Site, and one in the undeveloped filled portion of the Site. Air samples were collected at locations A-1 through A-5, shown on Figure 2-1.

Location A-3 was the background location, and was selected based on the wind direction on the day of sampling.

Two pumps were used at each sampling location to obtain the air samples. MSA Flow-Lite Pro personal sampling pumps were fitted with iodated carbon traps to collect atmospheric gaseous mercury at flow rates of 2 liters per minute (Lpm). Quartz wool plugs were placed in front of the traps to exclude any atmospheric particulate material. In addition, Gilian AirCon-2 or Dawson High Volume air samplers were fitted with quartz fiber particulate filters to collect particulate mercury samples at flow rates of 20 Lpm. A Gilian Gilibrator Calibrator was used to calibrate the flow rate through the pumps before and after the sampling period.

The second round of sampling was conducted to monitor the ambient air during the test-pit excavations. Six samples were collected from the perimeter of the undeveloped filled area of the Site. As in the first round of sampling, iodated carbon traps were used to collect gaseous mercury with SKC low-flow pumps (Model 224 TCXR4) at flow rates of 2 Lpm. An M-5 mini-Buck Calibrator was used to calibrate the pumps at the beginning and end of each sampling day. Each trap sampled air during the three days while the test pits were being excavated. When no sampling was taking place, the traps were capped and stored overnight in sealed double bags using ultra-clean handling techniques. The air sampling logs are included in Appendix H. The six sampling locations (B-1 through B-6) are shown on Figure 2-1.

2.7.3 Deviations from the Work Plan

The Work Plan specified that nuisance dust was to be determined gravimetrically on the particulate filter. The 8-hour sampling period was too short to provide enough particulate material on the filter for a precise measurement of nuisance dust. Only the concentration of elemental mercury in particulate form was measured on the filter.

The sampling pump at location A-4 did not run for eight hours on September 4, 1997, so sampling was not completed at this location. BBL returned to the Site and recollected the sample at this location on October 14, 1998. All sampling and analytical procedures were the same as those conducted for the other sample locations on September 4, 1997.

A second round of air sampling was conducted during the test-pit excavation to monitor the Site's perimeter for gaseous mercury during trenching activities.

2.8 HAZARDOUS SUBSTANCE INVENTORY

2.8.1 Objectives

The objective of the hazardous substance characterization task was to inventory all potentially hazardous substances encountered in the undeveloped filled area during the Site investigation. In addition, leaking contents and compromised drums exhumed during the test-pit excavations were to undergo hazardous waste characterization analysis, for the purpose of determining appropriate management of the exhumed materials. The results of these analyses are presented in Appendix B, Table B-10. Information regarding buried potentially hazardous substances was collected during the excavation of test pits from March 16 through March 18, 1998. Information regarding potentially hazardous substances located on the ground surface was obtained during a thorough Site walk on March 18 and 19, 1998.

2.8.2 Approach

During the test-pit excavations, three compromised drums were encountered and sampled. These samples were submitted to the lab for full waste characterization analysis. Only one of these drums was in good enough condition to be removed and overpacked; the other two were too severely deteriorated. During the Site walk, samples

were collected from three surface drums and four potentially hazardous surface samples. The sampled materials, as well as any other potentially hazardous material, were described in the field notes and photographed. All sample descriptions are contained in the hazardous substance inventory logs (Appendix I), and the analytical results are reported in Appendix B, Table B-10. The locations of the surface drums and surface samples (HS-1 through HS-7) are shown on Figure 2-1.

2.8.3 Deviations from the Work Plan

No deviations from the Work Plan occurred during the hazardous substances characterization task.

2.9 TOPOGRAPHIC AND LOCATION SURVEY

2.9.1 Objectives

The objectives of the surveying services were to: 1) establish a 100×100-ft control grid in the undeveloped filled portion of the Site; 2) establish the horizontal positions for sample locations, wetland delineation, geophysical survey, and other Site features; 3) establish vertical positions of surface-water and groundwater elevation measurement locations; 4) determine the Site boundary and locations of nearby physical and cultural features; and 5) determine the Site topography. Surveying activities were performed at the Site between October 1997 and May 1998.

2.9.2 Approach

A State of New Jersey licensed land surveyor performed all surveying work on the Site. The control grid was established prior to onsite surface soil sampling. Each grid point

was marked with a 2×2-in. wooden survey hub, and by an adjacent survey pin flag for greater visibility. All surveyed locations were established to within 0.01 ft using the New Jersey Plane Coordinate System datum. Vertical elevations were established to within 0.01 ft using the National Geodetic Vertical Datum of 1988. Horizontal and vertical control originated from the nearest New Jersey Geological Survey monument. All survey data were transferred electronically to Exponent in AutoCAD format. A "leaf-off" aerial photograph of the Site was taken November 27, 1997, and was used to prepare the topographic survey. Plate 1 depicts the Site topography, and the photograph is the basis of the Site map, Figure 1-2.

2.9.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during the topographic and location survey.

2.10 CULTURAL RESOURCES INVESTIGATION

2.10.1 Objective

The objective of the cultural resources investigation was to discover any potential historical or cultural resources contained within the Site that could be disturbed through remediation and development. The results of the study were presented previously in a separate bound report, *Phase IA Cultural Resource Investigation, the Wood-Ridge Site* (CRCG 1997). The investigation of the cultural resources at the Site occurred in June and July of 1997.

2.10.2 Approach

In accordance with Section 106 of the National Historic Preservation Act, a phase IA (reconnaissance level) cultural resource survey was conducted. A visual reconnaissance of the Site was conducted, and an extensive body of literature pertaining to the Site specifically, and to the region as a whole, was reviewed to evaluate the cultural and historical value of the Site.

The literature review covered a wide range of topics and time periods. Records were examined for evidence of cultural resources ranging from prehistoric occupation, to early European settlement, to construction of modern turnpikes. Sources contained information on topics such as agriculture, mosquito control, railroad construction, commercial development, and land use planning. The background research was conducted using State files, historical maps, USDA soils information, and various other secondary sources.

The visual reconnaissance was conducted on July 2, 1997, with the purpose of identifying any visible surface signs of cultural resources, examining the environmental setting, and determining the extent of ground disturbance. Inspection of the Site's perimeter, architectural features, topographic anomalies, areas of ground disturbance, and clearing were key components of the Site inspection.

2.10.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during the cultural resources investigation.

3.0 PHYSICAL CHARACTERISTICS OF THE SITE

The following section provides an overview of the physical characteristics of the Site, including information on its topography, geology, soils, hydrology, climate, land use, ecology, and demography. The information in this section is based on observations made during the Phase I investigation and from previous investigations and the literature.

3.1 TOPOGRAPHY AND SURFACE FEATURES

The 38-acre Site includes three distinctly different areas (see Figure 1-2): the 7-acre developed area, the 19-acre undeveloped filled area, and the 12-acre marsh area. The topography across most of the Site is generally flat, ranging in elevation from 0 to 12.6 ft above mean sea level. The highest elevation is found near the middle of the undeveloped filled area, and the lowest elevation is found in the marsh area.

Two warehouses occupy most of the developed area of the Site. The rest of the developed area is covered by asphalt-paved surfaces or railroad track. A set of railroad tracks is located immediately behind the warehouses on a bed of gravel. The elevation of the developed area varies from 4.3 to 5.8 ft. [The area between the warehouses contains a drainage ditch that is often filled with water.]

The undeveloped filled area of the Site is characterized by mixed vegetation and a variety of surficial debris. Much of this area is relatively flat, but the northeast portion of this area has uneven terrain. The highest point, 12.6 ft, is within 100 ft of the lowest point in the undeveloped filled area, at 3.4 ft. This low point is a small, rubble-filled pit. The only other significant surface feature in the undeveloped filled area is a small basin. The south and east perimeters of this area are steep stream banks adjacent to Berry's Creek and the Diamond Shamrock/Henkel ditch (north). The north and west perimeters of the area are fenced; additional fencing to the east prevents Site access via the tide gate.

The marsh area contains a near-monoculture stand of common reed (*Phragmites*). A small drainage ditch extends lengthwise through the middle of the marsh area all the way to Nevertouch Creek. The marsh area has the lowest overall elevation, with a maximum of 1.5 ft. At high tide, much of the marsh area is completely submerged. At low tide, the water drains, exposing sloping stream banks. Surface-water hydrology is discussed more thoroughly in Section 3.5.

3.2 CLIMATE AND METEOROLOGY

The climate in northeastern New Jersey is temperate continental (Trewartha 1968). Climate data cited in this report are from the National Oceanic and Atmospheric Administration (NOAA) data station located in Newark, New Jersey (15 miles south of the Site). The 1997 annual summary for this station can be found in Appendix J. The period of record for all climate data cited here is a minimum of 44 years.

Easterly winds, particularly southeasterly, moderate the temperature because of the influence of the Atlantic Ocean. The mean annual temperature is 54.2°F. July, the hottest month, has a mean maximum temperature of 84.6°F and mean minimum temperature of 66.9°F. January, the coldest month, has a mean maximum temperature of 38.5°F and a mean minimum temperature of 24.2°F (NOAA 1997).

Considerable amounts of precipitation fall during ocean-driven storms called Northeasters, which occur primarily in the autumn and winter. Annual precipitation averages 44 in., which includes 27 in. of snowfall. The driest month, February, has a mean precipitation of 3.0 in., and July, the wettest month, has a mean precipitation of 4.5 in. (NOAA 1997).

Low-lying ridges several miles to the northwest influence the winds flowing from the Atlantic Ocean over the region's generally flat, marshy terrain. Wind direction is predominantly from the northeast to the southwest, although during January through

April, the wind tends to blow more from the southeast to the northwest. Annual average wind speed is 10.2 miles per hour, with higher-than-average wind speeds from January through April (NOAA 1997).

3.3 GEOLOGIC SETTING

The Site is located in the Newark Basin, a rift basin that reaches from southern New York through northern and central New Jersey and into southeastern Pennsylvania. The southeastern and northwestern boundaries of the Newark Basin are defined by normal faults that strike northeast, between which the basin floor moved downward during the late Triassic Period (Carswell 1976).

The Newark Basin contains sedimentary rocks that were deposited during the Triassic and Jurassic Periods as the rift expanded to the northwest and southeast, and the center of the rift deepened. These sedimentary rocks consist primarily of sandstone and shale. During the Jurassic Period, igneous rocks were emplaced in layers between the sedimentary rocks. The igneous rocks include basalt, which is a volcanic rock that was extruded onto the sediments as they were forming, and diabase, which was intruded into the buried sediments. The basalt and diabase are similar mineralogically, consisting primarily of pyroxene and plagioclase (Carswell 1976). Collectively, these sedimentary and igneous rocks are known as the Newark Supergroup (Lytle and Epstein 1987). The Newark Supergroup rocks generally strike to the northeast and dip approximately 10 to 15 degrees to the northwest.

The bedrock beneath the Site is the upper Triassic–lower Jurassic Passaic Formation (formerly known as the Brunswick Formation). The Passaic Formation consists of reddish-brown shale, siltstone, and sandstone. In the northeastern part of the Newark Basin, the Passaic Formation is approximately 9,000 ft thick (Lytle and Epstein 1987).

The unconsolidated surficial deposits that cover the bedrock in the region of the Site include material related to the glacial episodes of the Pleistocene Epoch, and alluvium deposited by present-day streams on the glacial material. The glacial units consist primarily of varved lake deposits deposited in glacial Lake Hackensack. The varves are thin (1/16 to 1/2 in.), alternating layers of clay- to sand-sized particles. Each pair of silt and clay layers represents one annual cycle of deposition (Bloom 1978). The varved deposits can be up to 300 ft thick. The glacial units also include till laid down during glacial advances and retreats (Carswell 1976).

The youngest units in the vicinity of the Site are thin, Holocene alluvial deposits, such as sand and gravel. In addition, meadow mat, also known as root mat, is present in much of the area and consists of decayed vegetation and silt. The meadow mat can be from 10 to 50 ft thick. In some areas, silt and fine-grained sand underlie the meadow mat (Carswell 1976).

Previous geotechnical studies of the Site (J. S. Ward 1974, 1975) indicate that the unconsolidated units at the Site are consistent with those described in the region. These units are also described in the BITM (Volume 3). With increasing depth, these units include the following.

- Surficial fill, in the undeveloped filled area, consisting of gravel, sand, silt, and clay, with shale fragments as well as glass, brick, cinders, porcelain, wire, leather, cloth, coal, chemical matter, wood, shingles, rubber, plastic, metal, and other debris. The fill ranges in thickness from approximately 2 ft in the developed area of the Site, to a maximum of 21 ft near the center of the undeveloped filled area of the Site. Fill is not known to be present in the marsh area.
- Meadow mat, consisting of fibrous organic peat and silt, which ranges from 0.5 to 4.0 ft thick. The meadow mat is thinnest beneath the filled area of the Site, where it appears to have been compressed by the overlying fill.

- A 5- to 10-ft-thick layer of fine to medium-grained sand.
- A varved, gray to red-brown silt that is 62 to 146 ft thick.
- A red-brown silty sand unit that is at least 20 ft thick.

The previous geotechnical studies, which included borings as deep as 172 ft bgs, did not encounter bedrock.

3.4 SURFACE AND SUBSURFACE SOILS

3.4.1 Developed Area

There is no exposed soil in the developed area. Much of the developed area of the Site is occupied by the Wolf and U.S. Life warehouses. The remainder of the developed area of the Site is covered with asphalt pavement, or at the rear of the warehouses, covered with gravel, which forms the bed for the railroad tracks in this area.

The shallow soil in the developed area consists of black and brown silt and sand, with fill materials such as concrete and bricks. Boring logs of wells MW-8, MW-9, MW-10, and MW-11, which were installed in the developed area by the NJDEP in 1990, indicated that white, gray, and black sand and gray and black clay were present in this area to depths of 16 ft bgs. Fill materials were not reported on the well installation logs (Appendix K), suggesting that fill materials in this area are confined to the shallow soil. J.S. Ward (1974) reported a 2- to 3-ft-thick layer of fill consisting of clayey granular material with shale fragments overlying a 6- to 12-in.-thick layer of black organic silt with roots. This report also recommended placement of clean granular fill to raise the grade prior to building the warehouses.

3.4.2 Undeveloped Filled Area

Shallow soil in the undeveloped filled area consists of brown sand and silt, with some organic material such as roots. Small amounts of gravel and clay are also present in some locations. Additionally, surficial fill materials such as those listed in Section 3.3 are found throughout the area. Boring logs of wells MW-1 through MW-7, and MW-12, which were installed in the filled area by the NJDEP in 1990, indicated that subsurface soil consisted of a mix of sand, silt, and clay to depths of 20 ft bgs. Other materials, including wood and "trash," were also observed at these locations. Copies of NJDEP well installation logs are provided in Appendix K.

Additional information regarding the variety of surficial fill materials was obtained during the test-pit excavations (Section 2.2.2). A summary of fill materials encountered is listed below, and more complete descriptions can be found in the test-pit logs (Appendix D).

- Drums: Large and small metal and fiberboard drums, both empty and filled with a variety of substances (paint-, resin-, crystalline-like materials)
- Glass: bottles, beads, and large quantities of other broken glass
- Plastic: sheeting, film, cabling, rods, bottles
- Rubber: tires, rubber hoses
- Metal: pipes, appliances, automobile parts, scrap metal
- Construction debris: plywood, tar paper, shingles, brick, tiles, cement slabs, cinder blocks
- Other miscellaneous items: toilet, sink, washing machine, refrigerator, paper products, cardboard, rolls of colored foil, rags, wood, wood chips, sludge.

3.4.3 Marsh Area

Shallow soil in the marsh area consists of black to brown silt and roots. During sample collection, the soil at most locations was saturated within the 0–2 ft bgs sampling interval. The depth of saturation observed during soil sample collection was likely related to the tidal cycle. Sampling within the marsh area generally occurred from low to mid-tide.

3.5 SURFACE-WATER HYDROLOGY

3.5.1 Surface-Water Drainage Network

Surface-water drainage at the Site is generally to the southeast, where the Site is bordered by Berry's Creek. The three ditches that drain the southern (marsh) part of the Site are described below (see Figure 1-2). The marsh portion of the Site reportedly floods to a depth of up to 2 ft during high tide (J.S. Ward 1975). Field staff for this remedial investigation observed that, as the flood tide drains this area, the bulk of the water flows through a channel along the eastern edge of the marsh to Nevertouch Creek, before converging with Berry's Creek. The flow of water is diverted back to the Berry's Creek channel during low tide. There are no well-defined drainage patterns for the undeveloped filled area. The developed area is paved, and drainage generally is directed toward the drainage ditch between the warehouses. Drainage from this area flows along the western property boundary toward the Diamond Shamrock/Henkel ditch (north).

The Diamond Shamrock/Henkel ditch (north), which marks the boundary between the undeveloped filled portion of the Site and the marsh portion, flows in a southeasterly direction into Berry's Creek. The Diamond Shamrock/Henkel ditch (south) is coincident with the Site's southwestern property boundary and converges with Nevertouch Creek, which then forms the southern Site boundary up to its confluence with Berry's Creek. A

drainage ditch is roughly halfway between the two ditches. The Diamond Shamrock/Henkel ditch (south) is an open drainage channel that is fed by Nevertouch Creek and Berry's Creek. Prior to 1997, the south ditch provided the former Henkel plant production pond with non-contact cooling water. After use, the cooling water, together with storm water from the facility, would drain into the Diamond Shamrock/Henkel ditch (north) before discharging to Berry's Creek (IT 1988).

Berry's Creek flows generally south from the Site in a 4-mile course through tidal marshes before joining the Hackensack River. Much of the stream course is curving. The stream flow in the last 1.25 miles of this creek has been diverted to a straight, man-made channel known as Berry's Creek Canal. The overall drainage pattern of the Hackensack Meadowlands is anastomotic (meandering and braided), which is common in tidal marshes (Bloom 1978). The Hackensack River then flows southward into Newark Bay.

3.5.2 Surface-Water Elevation and Tidal Action

The tide gate, adjacent to the Site, divides Berry's Creek into an upstream and a downstream reach. Surface-water-level measurements made during the hydrogeological tidal study, January 14–16, 1998, are shown in Figure 3-1. The surface-water elevation fluctuates tidally, with a mean elevation only slightly higher than mean sea level. The surface-water elevation at low tide is approximately the same upstream and downstream of the tide gate. The tidal range in the upstream reach is approximately 2 ft, while in the downstream reach, the tidal range is approximately 6 ft. Therefore, at high tide, the surface-water elevation downstream of the tide gate is approximately 4 ft above that in the upstream reach. Surface-water elevations in the upstream reach vary depending on the tide gate configuration and the amount of debris caught in the gate.

The surface-water elevation on the downstream side of the tide gate was measured and recorded for a week-long period from October 24 through October 31, 1997 (during a

neap tide). These observations indicated a tidal range of approximately 7 ft, 1 ft greater than measured during the hydrogeological tidal study. Surface-water elevations are discussed further in Section 3.5.2.

The tidal range of Berry's Creek has been reported in several other studies as ranging between 5.5 and 6 ft (ERM 1985). These measurements were made 1.8 miles downstream of the Site. The mean tidal range where Berry's Creek Canal joins the Hackensack River is approximately 4.5 ft (HMDC 1982).

3.5.3 Frequency and Extent of Flooding

The proximity of the Site to Berry's Creek causes frequent flooding of certain areas of the Site. Portions of the marsh area are flooded twice a day, during the high tide. A larger portion of this area is flooded during higher tide events, such as spring tides and storms. The entire marsh area and much of the developed area of the Site are within the 10-year flood zone. The remainder of the developed area and portions of the undeveloped filled area are within the 100-year flood zone. Figure 2-9 of the BITM (Volume 3) shows a map of Berry's Creek next to and downstream of the Site, identifying areas of 100-year and 10-year floods.

3.6 GROUNDWATER HYDROGEOLOGY

3.6.1 Regional Hydrogeology

Groundwater occurs in a network of joints and fractures in the Passaic Formation. The consolidated rock between the joints and fractures generally does not contain significant amounts of groundwater, although sandstone beds commonly have moderate intergranular porosity. The joints and fractures are typically found within fissile mudstones and siltstones and are parallel to bedding (which strikes northeast and dips 10 to 15 degrees to the northwest), forming tabular aquifers that are separated by massive

layers that act as aquitards. Other major joint systems are perpendicular to bedding and strike northeast. The net result is that groundwater flow in the Passaic Formation is predominantly in the direction of strike (Houghton 1990). Fresh groundwater in the Passaic Formation in the Hackensack River Basin is generally limited to depths of less than 200 ft bgs (Carswell 1976).

Groundwater also occurs in the pores of the unconsolidated units that overlie the Passaic Formation. However, much of the unconsolidated material, such as the varved silts and clays, and glacial tills, have low permeability and are not significant sources of groundwater. Unconsolidated sands and gravels have greater permeability, but these units are generally thin and areally restricted, so the amounts of groundwater produced are not significant (Carswell 1976).

Groundwater is recharged principally through infiltration of precipitation in the topographically higher portions of the groundwater basin. Deeper groundwater discharges directly to the ocean, while shallower groundwater generally discharges to the surface-water bodies in the area, such as Berry's Creek and the Hackensack River.

3.6.2 Site Hydrogeology

The investigation of Site hydrogeology included a tidal study to determine the degree of tidal influence on groundwater elevations, three rounds of synoptic groundwater-level measurements, and hydraulic conductivity tests. These three studies are described below.

3.6.2.1 Hydrogeologic Tidal Study

The tidal study included periodic water-level measurements at six onsite wells and at two locations in Berry's Creek (one upstream and one downstream of the tide gate) for approximately 48 hours on January 15 and 16, 1998. Light rain and snow fell

intermittently during the tidal study, beginning 20 hours after the study began and ending 18 hours later. The amount of precipitation measured in an onsite rain gauge during this period was 0.07 ft.

Figure 3-1 is a hydrograph that illustrates the results of the tidal study. Water-level variations in each monitoring well over the duration of the tidal study are shown as solid lines. Water-level variations in Berry's Creek appear as solid ovals, because measurements were made by hand at less frequent intervals than the measurements made by the electronic data loggers in the monitoring wells. Each dot represents one water-level measurement in Berry's Creek. The predicted tidal variations for periods when measurements were not made are shown as open ovals.

As shown in Figure 3-1, water levels in wells MW-7, MW-12, and Berry's Creek increased slightly during the latter part of the test. This may be related to the precipitation that occurred during the monitoring period.

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The water elevation on both sides of the tide gate at low tide was approximately 3 ft below mean sea level (MSL). Surface-water elevations downstream of the tide gate rose sharply as high tide came in, but the tide gate prevents an increase of similar magnitude upstream of the gate. The tidal elevation variation in Berry's Creek was approximately 6 ft downstream of the tide gate, and 2 ft upstream of the tide gate.

Water levels in Berry's Creek upstream and downstream of the tide gate were consistently lower than groundwater levels in all the monitoring wells included in the tidal study, except as noted below. This indicates that groundwater from the Site discharges to Berry's Creek during the entire tidal cycle. The only exceptions to the observation that the surface-water level in Berry's Creek is lower than groundwater are as follows.

- At high tide, the water level in Berry's Creek downstream of the tide gate is higher than the water level in well MW-6. MW-6, however, is

located approximately 280 ft north (upstream with respect to Berry's Creek) of the tide gate and showed no response to tidal fluctuations. Therefore, it is unlikely that the water level in Berry's Creek downstream of the tide gate would influence the water table in the vicinity of MW-6.

- During high tide on January 16, 1998, the surface-water level in Berry's Creek downstream of the tide gate was slightly (approximately 0.2 ft) higher than the groundwater level in monitoring well MW-4. The groundwater level in MW-4 did not fluctuate in response to the tide.

Groundwater elevations in five of the six wells (MW-1, MW-2, MW-4, MW-6, and MW-7) included in the tidal study did not show any variation that coincided with the tides in Berry's Creek. The only well that exhibited any tidal fluctuation was MW-12. The range of water-level elevations in this well was less than 0.5 ft, suggesting a small, but measurable, influence by tides in the Diamond Shamrock/Henkel ditch (north) on groundwater in the area of MW-12.

Although the water level in MW-12 fluctuated, the groundwater elevation in this well did not change enough to alter the direction of the gradient relative to the other wells monitored during the tidal study (excluding the latter part of the test, when water levels were apparently influenced by precipitation). Specifically, the water level in MW-12 was always greater than the water level in MW-6, and less than the water levels in the other wells. The lack of significant changes in groundwater elevation during the tidal study indicates that the groundwater flow direction at the Site is not influenced by the tides in Berry's Creek. Therefore, groundwater elevation measurements made at any time during the tidal cycle should provide an adequate representation of the groundwater flow direction at the Site.

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A mean groundwater elevation was calculated for each monitoring well included in the tidal study, and for the measuring points on Berry's Creek, using the method of Serfes

(1991). Data from the first 25 hours of the test (before precipitation influenced the water levels) were used for this calculation. The results of the calculation are shown as a groundwater elevation contour map in Figure 3-2. These data illustrate the mean groundwater flow direction in the undeveloped filled area during the tidal study. Based on the groundwater contours, flow in the northeastern portion of the filled area is toward the upstream reach of Berry's Creek. Groundwater flow in the southwestern portion of the undeveloped filled area is generally toward the Diamond Shamrock/Henkel ditch (north) and possibly toward Berry's Creek. These observations are discussed in greater detail below, using groundwater elevation data from all wells on the Site.

I think it is

3.6.2.2 Site-Wide Groundwater Flow Patterns

Water levels were measured in all onsite wells on October 15, 1997, December 9, 1997, and January 15, 1998. These data are summarized in Table 3-1. Figure 3-3 is a groundwater contour map prepared using the water-level data collected on December 9, 1997, which is the most complete set of measurements. The overall trends in the groundwater elevation data were essentially the same in all three sets of measurements (i.e., the directions of the gradient between wells did not change), so one set of measurements was selected to illustrate groundwater flow conditions at the Site. There were, however, some differences in the magnitude of the gradients between wells in the three sets of measurements.

The major features of the site-wide groundwater flow patterns are:

- A generally radial flow pattern is apparent in the undeveloped filled area, with the highest groundwater levels in monitoring wells MW-2 and MW-3. This is most likely caused by higher infiltration of water in the undeveloped filled area than in the surrounding developed areas.
- Along with the radial flow patterns, there is likely a small downward vertical component of flow generally in the center of the undeveloped

filled area, which then transitions to a small upward vertical flow component near the perimeter of the undeveloped filled area.

- As part of the overall radial flow patterns, groundwater in the northeastern portion of the undeveloped filled area flows in a northeasterly direction toward the upper reach of Berry's Creek (this flow pattern was also noted on Figure 3-2 using the tidal study data).
- Groundwater in the developed area flows generally north to south under the U.S. Life Warehouse and then likely turns to the west-southwest in response to the radial flow from the undeveloped filled area. (NW → SW)
- The combination of the radial flow pattern in the undeveloped filled area and regional flow from the north appears to create a groundwater divide, and possibly a stagnant zone in the vicinity of MW-7. (Have Dean look @ this)

The groundwater gradient in the northeastern portion of the Site, based on the groundwater elevations in wells MW-2 and MW-6, is 0.0084 ft/ft, which is a steeper gradient than in other portions of the filled area. The steep groundwater gradient in this area is likely due to the low surface-water elevation in Berry's Creek upstream of the tide gate, in comparison to surface water downstream of the tide gate.

Groundwater flow in the southwestern portion of the undeveloped filled area is toward the Diamond Shamrock/Henkel ditch (north) and toward Berry's Creek. Flow gradients are much lower in these areas than in the area near MW-6. The groundwater gradients in the developed area are steepest in the area southeast of Park Place East and below the U.S. Life Warehouse (0.0076 ft/ft from well MW-10 to MW-9).

3.6.2.3 Hydraulic Conductivity

Hydraulic conductivity was determined at each monitoring well using slug tests. Table 3-2 provides a summary of the results. The Aqtesolv[®] graphs showing the time vs. displacement field data are provided in Appendix E.

As shown in Table 3-2, the hydraulic conductivity values ranged from 1.6×10^{-4} ft/min at well MW-6 to 6.6×10^{-2} ft/min at well MW-4, a range of more than two orders of magnitude. The greatest variability in hydraulic conductivity was measured in wells located in the undeveloped filled area. This wide range of hydraulic conductivity values is most likely due to the heterogeneity in the fill materials in which the wells are screened. Well logs indicate that monitoring wells MW-1, MW-2, MW-4, and MW-6 all contain fill below the water level observed in these wells. Based on the Site history, observations during the test pit program, and their location, wells MW-3, MW-5, MW-7, and MW-12 may also be installed in fill materials (although fill was not reported in the NJDEP well installation logs [Appendix K]).

The wells in the developed area, including wells MW-8, MW-9, MW-10, and MW-11, exhibited a relatively narrow range of hydraulic conductivity values, from 1.8×10^{-3} to 9.1×10^{-3} ft/min. Based on the NJDEP well installation logs (Appendix K), these wells are screened in native sands and clays; fill was not observed during installation of these wells. This range of hydraulic conductivity values is typical of silty sand (Freeze and Cherry 1979).

3.6.3 Groundwater Classification

As described in the BITM (Volume 3), the aquifer beneath the Site has been designated as a Class II-A aquifer, in accordance with the New Jersey Ground Water Quality Standards (N.J.A.C. 7:9-6). The primary designated uses for Class II-A groundwater are potable water and conversion to potable water through conventional water supply

treatment, mixing, or similar techniques. Based on the proximity of the Site to a tidally influenced waterway, and the heavy industrial activities in the surrounding area, potable use of groundwater from the shallow aquifer beneath the Site is unlikely.

3.7 ECOLOGICAL DESCRIPTION

3.7.1 Vegetation Cover Types

The description of vegetation cover types in this section reflects conditions observed during two Site characterizations conducted on May 22, 1997, and May 7, 1998. During the 1997 Site characterization, the focus was on identifying vegetation structure and hydrology for evaluating potential wetland conditions. During the 1998 Site characterization, the focus was on evaluating the habitat structure and quality provided by vegetation cover types, and on documenting the presence of residential and/or transient wildlife.

3.7.1.1 Wetlands

Wetlands were delineated during the 1997 field season (see Section 2.6). The wetland delineation report was prepared and submitted as a separate document (Shisler 1997). Obligate wetland plant species that were identified and that indicate wetland presence included arrow arum (*Peltandra virginica*), pickerel-weed (*Pontederia cordata*), and smooth cordgrass (*Spartina alterniflora*). Most of these species were limited to the borders of Berry's Creek and the Diamond Shamrock/Henkel ditches. No rare, threatened, or endangered species are expected to occur or have been reported at the Site (Shisler 1997).

3.7.1.2 Upland Vegetation

Table 3-3 is a list of the plant species observed during the 1998 Site characterization. In general, upland vegetation covers the undeveloped filled portion of the Site. Plant species present are primarily non-native hardwoods and herbaceous weeds that are characteristic of urban regions. These species are expected based on the disturbed nature of the property and its location in an industrial area.

Vegetation categories in the undeveloped filled area can be distinguished based on structure. Three zones are commonly used in describing upland vegetation: canopy, understory, and groundcover. Each zone refers to the vertical "position" of vegetative species within the terrestrial environment. Canopy species include larger, more developed trees like oak and maple. Understory (i.e., below canopy) species include woody shrubs, saplings, and brush like sumac or knotweed. Groundcover, as its name implies, refers to creeping, sometimes rhizomatous, perennial species of weeds and grasses that cover the ground.

Figure 3-4 illustrates the approximate distribution of canopy species at the Site. As indicated in the figure, portions of the Site (mainly in the northernmost area) have an open canopy of trees, consisting of tree-of-heaven (*Ailanthus altissima*), black locust (*Robinia pseudo-acacia*), poplar (*Populus tremuloides*), cottonwood (*Populus deltoides*), mulberry (*Morus* sp.), choke cherry (*Prunus virginiana*) and sweet gum (*Liquidambar styraciflua*). Older and larger trees reach estimated heights exceeding 75 ft. Other portions of the Site (to the south and west) show smaller, more fragmented stands of canopy that comprise a similar mix of species.

Figure 3-5 represents the distribution of understory species at the Site. The distribution of understory species, though somewhat fragmented, is mostly along the perimeter of the Site. This is particularly true for eastern, western, and southern portions of the undeveloped filled area. One reason for this distribution pattern is that a key species of the understory, the common reed (*Phragmites australis*), is associated with the low-lying

disturbed areas that border Berry's Creek and the Diamond Shamrock/Henkel ditch (north). Figure 3-6 shows the approximate distribution of common reed at the Site. Note that the distribution as shown in Figure 3-6 is similar to that in Figure 3-5, indicating that common reed is the dominant understory species. Other vegetation beneath the tree canopy includes sumac (*Rhus copallinum*), wild rose (*Rosa multiflora*), knotweed (*Polygonum cuspidatum*), and saplings of hardwood species. A thick layer of herbaceous weeds—primarily mugwort (*Artemisia vulgaris*)—is present as groundcover throughout most of the undeveloped filled area of the Site.

Photographs in Figure 2-10 of the BITM (Volume 3), taken in May 1997, illustrate vegetation on the undeveloped filled portion of the Site. Figure 2-10, photograph a, shows a canopy of relatively small tree-of-heaven with a weedy herbaceous layer. This photograph was taken in the northeastern quadrant of the undeveloped filled area of the Site. Figure 2-10, photograph b, taken close to photograph a, shows an area without a canopy of trees, with dense early-season growth of annuals, including common reed.

3.7.2 Wildlife

The ecological isolation and disturbed nature of the Site affect its wildlife resources. Primary local land uses are industrial, and a substantial transportation infrastructure is present (a railroad bed adjoins the Site, and municipal roadways and a state highway are present within a few hundred yards). As shown in the aerial photograph review (Section 2.4 of the BITM), the Site was significantly disturbed through filling, re-grading, vehicular traffic, ditch construction, and material disposal from 1940 through 1974. Common urban species of mammals (e.g., woodchuck [*Marmota monax*], Norway rat [*Rattus norvegicus*], opossum [*Didelphis virginiana*], cottontail rabbit [*Sylvilagus floridanus*], and muskrat [*Ondatra zibethicus*]) present at the Site are listed in Table 3-4.

Resident birds that are characteristic of human-influenced landscapes were commonly observed at the Site. Species observed included red-winged blackbird (*Agelaius*

phoeniceus), robin (*Turdus migratorius*), common grackle (*Quiscalus quiscula*), starling (*Sturnus vulgaris*), English sparrow (*Passer domesticus*), mourning dove (*Zenaidura macroura*), mockingbird (*Mimus polyglottos*), catbird (*Dumetella carolinensis*), blue jay (*Cyanocitta cristata*), and others (as listed in Table 3-4). Migratory species, including a number of warblers (Parulidae) and flycatchers (Tyrannidae), were observed onsite in the spring of 1997. Under baseline conditions, individual migrants likely are present for a few days to weeks in the spring and autumn. Other birds that are characteristic of the Hackensack Meadowlands as a whole may be present as transients. Herons, egrets, hawks, sandpipers, and plovers may be expected to forage in the Site vicinity, although nearby human activity and lack of onsite habitat for these species probably restricts foraging.

Lists of endangered, threatened, rare, or uncommon species for the Site vicinity, from the New Jersey Natural Heritage Database for Bergen County (March 1997), have been reviewed. These lists will be included with the ecological risk assessment report (to be submitted as a separate document). In general, species on these lists could be present where suitable habitat exists. Based on observations made during the field reconnaissance, however, endangered, threatened, rare, and uncommon species are not likely to be present on the Site. No wildlife management areas have been identified in the immediate vicinity of the Site. This information will be confirmed in the problem formulation phase of the ecological risk assessment, and through consultation with HMDC and New Jersey Natural Heritage Program personnel.

3.7.3 Upland Habitat Quality and Resource Value to Biological Communities

Habitat quality is related to an ecosystem's structural integrity and the attributes that support biological communities. At the Site, habitat quality is compromised by several physical factors. Ecological isolation of the Site (due to surrounding industrial and commercial land use) prevents recruitment of species and impairs diversity.

Furthermore, the long history of physical disturbances has created conditions favorable

for opportunistic vegetation that is characteristic of waste areas (e.g., tree-of-heaven, knotweed, and common reed). These physical factors have resulted in fragmented or impaired conditions that reduce habitat quality by preventing wildlife from establishing territories for nesting and foraging.

The value of habitat to biological communities can be evaluated by examining the direct use of its resources by individual organisms. Habitats with high resource value support "healthy" biological populations, whereas habitats with low resource value support less desirable species. One method for evaluating resource value is to examine the resource type (in this case, onsite terrestrial vegetation), along with the functional feeding habits of observed wildlife species. In Tables 3-5 and 3-6, seasonal diets of birds and mammals observed at the Site are compared to the type and abundance of plant species that make up some proportion of their diet (Martin *et al.* 1961).

This comparison illustrates several important factors. For most species of birds observed at the Site, the percent of plant material as part of the diet varies considerably within and among species (Table 3-5). Rarely do birds consistently eat plant matter throughout all of the seasons. Two species, the mourning dove and the English sparrow, have diets that are consistently 90 percent (or greater) plant matter throughout the year. However, on further examination of the plant types that these species are known to consume, only knotweed is present at the Site, and only at low to medium densities. Moreover, both the English sparrow and the mourning dove have been shown to consume knotweed at proportions equal to only 2 to 5 percent of their vegetative diets (Martin *et al.* 1961).

Other species, such as the robin, consume a lower percentage of plant material throughout the year than do the English sparrow and mourning dove. However, the robin is more likely to utilize a wider range of Site resources, as documented by the greater number of plant species that are available as food (Table 3-5). This means that the robin is more likely to benefit from the resources at the Site, even though these plant species are present in relatively low abundance. It is important to recognize that robins, and

other birds observed at the Site, are likely to use offsite foraging areas to supplement their dietary needs.

For mammals, similar patterns of resource value at the Site emerge. For example, woodchucks and cottontail rabbits are considered to forage throughout the year almost exclusively on plant matter (Table 3-6). Furthermore, herbaceous plants are their primary source of food and are abundant at the Site. Although a specific estimate is not available as to the percent of herbaceous plant consumption in their diet, it is reasonable to assume that this value is high. Combined, these factors suggest that the cottontail rabbit and woodchuck could be supported by Site habitat. Field observations on the presence and relative abundance of these animals indicate that this is a reasonable conclusion.

One other mammal present at the Site that is important to consider is the muskrat. Similar to woodchucks and cottontail rabbits, the muskrat's diet throughout the year is composed primarily of plant matter. However, the plant species that are commonly consumed by muskrat (e.g., cattail, common reed, pondweed, and arrowhead) are distributed more along the south and east perimeter of the Site where aquatic habitat is present (Figure 3-5). Moreover, the foraging range of muskrats has been documented to be between 5 and 10 m of their semi-aquatic houses (U.S. EPA 1993b). These factors suggest that the muskrat is not likely to utilize terrestrial resources at the Site.

In summary, several wetland and upland plant species occur at the Site. Many of these plants are typical of disturbed waste areas. Observations on bordering land use, and the distribution and abundance of onsite plant species, indicate a severely fragmented habitat. Wildlife use of the Site is limited to birds and mammals that are typically found in urban environments. An evaluation of habitat quality as a function of ecological isolation, low recruitment potential, and a historically disturbed environment suggests that habitat quality is poor for supporting most species of birds and mammals. Resource use suggests that most species of birds (with the possible exception of robins) are not likely to rely on the Site exclusively as habitat for foraging, or for nesting. Most of the birds are likely to use offsite foraging areas to supplement their dietary needs. Only resident mammals, as

represented by the woodchuck and cottontail rabbit, are likely to be supported by the abundance of herbaceous plants at the Site.

3.7.4 Wetlands Functional Assessment

Various methods have been used in the Hackensack Meadowlands District (HMD) to evaluate the functions of wetlands over the last 20 years. In preparing the Draft Environmental Impact Statement (DEIS) for the Special Area Management Plan (SAMP) for the HMD, the Indicator Value Assessment (IVA) method was used (U.S. EPA and ACOE 1995). The IVA is an indexing system developed specifically for the HMD that uses chemical, physical, and biological wetland functional indicators to assess wetland conditions. The IVA provides a "semi-quantitative" measure of wetland functional indicators. The IVA is based on the Wetland Evaluation Technique (WET) assessment methodology (U.S. EPA 1989). It utilizes data presented in the Advanced Identification of Wetlands (AVID) (U.S. EPA 1992a) that was previously conducted in the HMD. The Best Professional Judgment (BPJ) method in the IVA will be used in this evaluation of the functional assessment for the 15 acres of tidal wetlands on the Site.

The IVA evaluates wetland functions for the following three wetland attributes: 1) wildlife habitat; 2) water quality improvement; and 3) social significance. These functions are considered important by the IVA development team (composed of representatives from the EPA, HMDC, ACOE, and NJDEP).

3.7.4.1 Wetlands on Site

There are approximately 15 acres of wetlands in the southern section of the Site that consist of a dense monoculture of *Phragmites australis* (common reed). The wetland area is adjacent to Berry's Creek, with ditches present along the north and south sides of the wetlands. The wetland surface seems to be completely inundated only during the

spring tides and storm events. There is an absence of emergent and submerged aquatic vegetation along the Diamond Shamrock/Henkel ditches.

The results of the indexing method for the three wetland attributes are presented in the DEIS. These attribute scores do not reflect the size of the wetlands. The scores represent a kind of "value per acre," which allows comparison of the wetland attributes among different wetlands. The attribute scores were calculated using data collected during the 1987/88 WET/AVID study. The wetland attribute scores for the wetlands along Berry's Creek are (4B in the DEIS): Water Quality = 87; Wildlife Habitat = 71; and Social Significance = 1. The Berry's Creek wetlands are designated in the DEIS as "unimpacted wetlands" for the SAMP. Unimpacted wetlands are those that are unlikely for mitigation either because of existing high quality, existing contamination issues, or very small size.

3.7.4.2 Assessment of Wetland Functional Values

In the IVA, the BPJ method compares study wetlands with reference wetlands. This method could not be used here. Instead, the functions of the wetlands on the Site were compared with those of various wetlands previously evaluated by Shisler. In assessing the wetland functions for the wetlands on the Site, each attribute was given a rating from 0 to 10 (with 0 representing no value, and 10 representing the highest value). The assigned ratings and rationale for each attribute is listed in Table 3-7.

In conclusion, the *Phragmites*-dominated wetlands provide limited habitat for wildlife. Social significance is low, as a result of the low recreation and conservation potential. The major functions of the wetland are for water quality improvement and flood-flow alteration. This BPJ evaluation differs slightly from the DEIS evaluation for the Berry's Creek wetlands, in that the DEIS assigned a higher wildlife attribute rating.

3.8 DEMOGRAPHY AND LAND USE

The Site is located in an urban, industrialized area of Bergen County, just 6 miles east of New York City. The northern portion of the Site is located in the Borough of Wood-Ridge, and the southern portion is located in the Borough of Carlstadt. Wood-Ridge is a borough of 1.1 mi² (704 acres). The population of Wood-Ridge was estimated to be 7,506 persons in the 1990 census, representing a decline of almost 10 percent since the 1970 census (8,311 persons) (The New Jersey Municipal Data Book 1997). Carlstadt is somewhat larger, at 4.2 mi² (2,688 acres). The population of Carlstadt was 5,510 persons according to the 1990 census, a decrease of 10 percent from the 1980 census (6,166 persons) (The New Jersey Municipal Data Book 1998). There are approximately 11,600 people living within a 1-mile radius of the Site (U.S. EPA 1998).

The Site represents approximately 1 percent of the combined land areas of Wood-Ridge and Carlstadt. The Wood-Ridge portion of the Site (approximately 15.7 acres) includes all of the developed area and just less than half of the undeveloped filled area. Wood-Ridge has zoned this area as "light industrial park" (Kolicko 1997, pers. comm.). The Carlstadt portion of the Site (approximately 22.6 acres) includes all of the marsh area and just over half of the undeveloped filled area. This portion is located in a special zoning district regulated by HMDC. This portion is zoned as "light industrial and distribution B."

The areas to the north and west of the Site, within the Borough of Wood-Ridge, are occupied by single-story industrial structures and residential housing. The one-block area immediately north of the Site, between Blum Boulevard and Anderson Avenue, is zoned by the Borough of Wood-Ridge as "light industrial park." Residential zoning exists 750 ft to the north, where there are approximately 50 residential properties, both single- and multi-family units (Thornley 1998, pers. comm.). This residential area continues to the north but is located in the Borough of Moonachie and is under the jurisdiction of the HMDC. This area is zoned "low density residential" (HMDC 1986). Immediately to the west are warehouses and other industrial properties. Five-hundred feet to the west is

New Jersey State Route 17, a four-lane divided highway. Additional residential properties within the boroughs of Wood-Ridge and Carlstadt are located beyond Route 17 to the west.

4.0 NATURE AND EXTENT OF CONTAMINATION

This discussion of the nature and extent of contamination is based on the data collected during the Phase I remedial investigation, and on NJDEP's previous investigations during the period 1990 to 1991 related to the Site. The metals and organic compounds identified as SoPCs in Section 1.4 (see Table 1-2) are discussed here for the specific media in which they were identified as being of potential concern. Tables and figures referred to in this section present summaries of the data. Summary tables for soils and sediment incorporate SVOCs and metals identified as SoPCs for all media. The summary table for groundwater includes metals identified as SoPCs for all media and VOCs. Summary tables for seeps and surface water incorporate metals identified as SoPCs for all media. SoPCs for the specific medium shown in a given table are indicated by bold typeface. Because of the complex nature of the environmental samples collected, and variable dilution of laboratory sample extracts, instrument detection limits (IDLs) for SoPCs vary widely. Only concentrations above IDLs were used in calculating the ranges and geometric means presented in the summary tables. Complete tables of all Phase I investigation data are presented in Appendix B. Analytical results for quality assurance samples collected in the field (sample duplicates, equipment rinsate blanks, and trip blanks) are found in Appendix L. Data quality assurance review summaries, laboratory case narratives, and nonconformance summaries are presented in Appendix M.

Section 4 is organized into eight subsections. Sections 4.1 through 4.5 discuss the nature and extent of SoPCs in the various media: soil, groundwater, leachate/seeps, surface water, and sediment. Section 4.6 discusses the results from two rounds of air sampling. Section 4.7 discusses the concentrations of substances found at elevated levels in the material collected from the Site during the trenching activities and hazardous substance inventory investigation. Each section is further organized in subsections that discuss the data in the following order: mercury, other metals, and organic compounds. The summary tables and discussions are also organized in terms of three distinct areas of the

Site: the developed area, the undeveloped filled area, and the marsh area. Section 4.8 discusses the data quality assessment.

The results presented in this section support the transport and fate discussion in Section 5, as well as the future baseline human health and ecological risk assessments and feasibility study.

4.1 SOILS

4.1.1 Onsite Surface Soil Analyses

This section summarizes the measured concentrations of SoPCs in surface soils collected from 200-ft intervals on the 100×100-ft control grid established on the Site within the undeveloped filled area, the marsh area, and around the perimeter of the warehouses. Onsite surface soils are defined as material collected from the 0- to 2-ft soil horizon, with rocks and debris removed. A total of six metals (arsenic, cadmium, copper, lead, mercury, thallium, and zinc) and four SVOCs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, and bis[2-ethylhexyl]phthalate) were identified as SoPCs (see Section 1.4). Table 4-1 provides a summary of analytical results for these SoPCs. Complete analytical results for onsite surface soil samples are presented in Appendix B, Table B-1.

4.1.1.1 Mercury

The highest mercury concentration in surface soils from the Site was measured at location SS-04 (13,800 mg/kg) near the vicinity of the former mercury processing plant (Figure 4-1). Small beads of elemental mercury were visible in this sample, which was collected from underneath the asphalt pavement. The remaining eight samples collected from locations around the perimeter of the two warehouses ranged from 9.3 to

1,485 mg/kg. The mean for the developed area is 317 mg/kg. Mercury concentrations in the undeveloped filled area ranged from 1.2 to 548 mg/kg, with a mean of 39.3 mg/kg. The sample collected from the southern-most location in this area (SS-34) exhibited the lowest concentration (1.2 mg/kg), whereas the highest concentration was measured at location SS-20 (548 mg/kg), near the center of this area. Mercury concentrations in marsh soils ranged from 25.1 to 1,090 mg/kg, with a mean of 166 mg/kg. The lowest and highest concentrations in this area were measured in soils from adjacent sample locations (SS-36 and SS-37, respectively). No soil samples collected from the Site had mercury concentrations below IDLs.

Methylmercury concentrations were measured in all 19 samples collected from the marsh area, in four samples along the transect bordering the Diamond Shamrock/Henkel ditch (north), and in five samples from other locations in the undeveloped filled area (Figure 4-1). Concentrations ranged from 0.0006 to 0.322 mg/kg. The mean concentration for nine locations in the undeveloped filled area was 0.005 mg/kg, and the mean for the marsh locations was 0.033 mg/kg. The lowest methylmercury concentration coincides with the lowest mercury concentration (SS-34), and the highest methylmercury concentration coincides with the highest mercury concentration in the undeveloped filled area (SS-20). The concentration of methylmercury relative to the concentration of total mercury in soils is discussed in Section 5, *Transport and Fate of SoPCs*.

Mercury was analyzed in surface soils collected during the installation of twelve monitoring wells by NJDEP in 1990. The concentration of mercury ranged from 1.6 to 1,820 mg/kg in the uppermost 2-ft (or 2.5-ft) soil boring intervals (Figure 4-2) (NJDEP 1993a). No surface soil samples were submitted for mercury analysis at locations MW-8 and MW-11. The concentrations of mercury in many of these soil samples were similar to those in samples collected from nearby locations in this Phase I investigation. For example, the samples with the lowest mercury concentrations in both studies were collected from sample locations within approximately 80 ft of each other (1.6 mg/kg at MW-4 and 1.2 mg/kg at SS-34). Samples collected from MW-6 (395 mg/kg) and MW-2 (588 mg/kg) have mercury levels similar to SS-12 (346 mg/kg) and SS-20 (548 mg/kg),

respectively. The highest mercury concentration was from sample location MW-10 in the developed area of the Site. Methylmercury was not measured during the NJDEP program.

4.1.1.2 Other Metals

The concentrations of metals other than mercury in the surface soils collected from the Site are presented in Figures 4-3 through 4-7 and summarized in Table 4-1. The following distributions were found for each metal:

- **Arsenic**—The highest concentrations of arsenic were found in soils from the marsh area of the Site (Figure 4-3), where concentrations ranged from 15.6 to 150 mg/kg, with a mean of 36.6 mg/kg. The samples with the highest concentrations (150 and 93.8 mg/kg) were collected from locations along the drainage ditch in the marsh (SS-40 and SS-41, respectively). Arsenic concentrations in surface soils throughout the rest of the Site were less than the screening criterion (20 mg/kg), and seven locations were below IDLs.
- **Copper**—Concentrations in the developed area ranged from 12.4 to 470 mg/kg, with a mean of 62.2 mg/kg (Figure 4-4). In the undeveloped filled area, copper ranged from 22.8 to 1,010 mg/kg, with a mean of 152 mg/kg, and in the marsh area, copper ranged from 44.2 to 730 mg/kg, with a mean of 297 mg/kg. The single highest value was found in the undeveloped filled area (SS-24), but the mean value for the undeveloped filled area is substantially lower than the mean for the marsh area.
- **Lead**—Unlike arsenic, lead concentrations were highest in the undeveloped filled area of the Site (see Figure 4-5). The concentrations in the undeveloped filled area ranged from 39.3 to

4,320 mg/kg, with a mean of 430 mg/kg, while soils from the developed area had the lowest measured concentrations for lead, and ranged from 17.8 to 390 mg/kg, with a mean of 71.4 mg/kg. The marsh area had fairly uniform levels of lead in soils, with a range of 51.6 to 401 mg/kg and a mean of 248 mg/kg.

- **Thallium**—Thallium was detected in only 12 of the 52 soil samples, 10 of which were from the marsh area, and two from the undeveloped filled area (Figure 4-6). Concentrations of thallium in the marsh samples ranged from 6.2 to 24.4 mg/kg, with a mean of 11.5 mg/kg. The two samples from the undeveloped filled region (SS-08 and SS-20) had thallium concentrations of 14.5 and 21.9 mg/kg, respectively. All samples from the developed area were below IDLs. This general pattern is similar to that observed for copper and zinc.
- **Zinc**—The distribution of zinc in surface soils follows a pattern similar to copper and thallium (see Figure 4-7). The highest concentrations of zinc in the undeveloped filled area were located at SS-08 (14,400 mg/kg) and SS-20 (25,400 mg/kg). Concentrations of zinc from the remaining sample locations in this area ranged from 192 to 6,570 mg/kg. The mean concentration for the undeveloped filled area was 1,312 mg/kg. Concentrations of zinc in the marsh area were, on the average, greater than the undeveloped filled area. They ranged from 868 to 22,700 mg/kg, with a mean of 3,073 mg/kg. In the developed area, concentrations ranged from 88.9 to 1,100 mg/kg, with a mean of 371 mg/kg.

The results for surface soil samples collected during the installation of monitoring wells by NJDEP in 1990 indicated concentrations of inorganic substances above NJDEP Interim Soil Action Levels (1990a) for location MW-7. No other surface soil samples were submitted for determination of TAL metals. The concentration of copper in the 0- to 2-ft soil horizon at MW-7 was 332 mg/kg. Thallium and zinc concentrations were

10 mg/kg and 10,600 mg/kg, respectively, from that same sample. During the recent investigation, soil samples were not collected from this exact location; however, soil samples from five locations within a 200-ft radius of MW-7 ranged from 88.4 to 343 mg/kg for copper, were below IDLs for thallium, and ranged from 383 to 918 mg/kg for zinc.

4.1.1.3 Semivolatile Organic Compounds

Four of the 64 SVOCs in the analyte list for onsite surface soils were identified as SoPCs. They are benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, and bis[2-ethylhexyl]phthalate. Mean concentrations of benz[a]anthracene, benzo[a]pyrene, and benzo[b]fluoranthene did not vary substantially among the different areas of the Site, although maximum concentrations were higher in the undeveloped filled and marsh areas than in the developed area. *Did fill come from Bldg#2 development*

Concentrations of benzo[a]pyrene exceeded the screening criteria (660 $\mu\text{g}/\text{mg}$) at 12 surface soil locations; nine in the undeveloped filled area, two in the marsh area, and one in the developed area (Figure 4-8). The highest concentrations were from sample locations SS-17 (3,200 $\mu\text{g}/\text{kg}$), SS-29 (10,000 $\mu\text{g}/\text{kg}$), and SS-36 (4,900 $\mu\text{g}/\text{kg}$). These locations are adjacent to the western Site property line that borders Randolph Products and Diamond Shamrock/Henkel. The concentration of benzo[b]fluoranthene was also greater than screening criterion (4,000 $\mu\text{g}/\text{kg}$) at these sample locations. The concentration of benz[a]anthracene was greater than the screening criterion (4,000 $\mu\text{g}/\text{kg}$) only at sample location SS-36.

The mean concentration of bis[2-ethylhexyl]phthalate was substantially higher in the undeveloped filled area than in the other two areas of the Site. Two samples from this area, SS-18 and SS-24, have concentrations an order of magnitude higher than soil samples collected from other locations on the Site (380,000 and 290,000 $\mu\text{g}/\text{kg}$,

respectively). The concentrations for the remainder of the soil locations were below the screening criterion and ranged from 87 to 22,000 $\mu\text{g/kg}$.

Surface soil (0–2 ft) collected during the installation of monitoring wells by NJDEP in 1990 contained measurable concentrations of 14 SVOCs for one sample location (MW-7) (NJDEP 1993a). Three of these substances are included in the list of SoPCs for this investigation: benzo[fluoranthene] (480 $\mu\text{g/kg}$), benzopyrene (330 $\mu\text{g/kg}$), and bis[2-ethylexyl]phthalate (480 $\mu\text{g/kg}$). The concentrations of these SVOCs from five nearby locations collected during the Phase I investigation ranged from 180 to 1,500 $\mu\text{g/kg}$ for benzo[b]fluoranthene, 480 to 3,200 $\mu\text{g/kg}$ for benzopyrene, and 2,300 to 380,000 $\mu\text{g/kg}$ for bis[2-ethylexyl]phthalate.

4.1.2 Onsite Subsurface Soil Analyses

This section summarizes the measured concentrations of SoPCs in subsurface soils collected from 20 test pits located in the undeveloped filled portion of the Site. Two subsurface soils were collected from test pits 1–10 and 13–20. A single subsurface soil sample was collected from test pits 11 and 12, because the depths of these test pits were less than 3 ft. A total of seven metals (arsenic, cadmium, copper, lead, mercury, thallium, and zinc) and two SVOCs (benzo[a]pyrene, and benzo[b]fluoranthene) were identified as SoPCs (see Section 1.4). Table 4-2 provides a summary of analytical results for SoPCs. Complete analytical results for onsite subsurface soil samples, including the depth of collection, are presented in Appendix B, Table B-3.

In addition, nine discretionary soil samples were collected from the test pits. Discretionary samples were selected where discolored material or waste deposits were evident in the test pits and were not part of the 2-ft soil intervals sampled from the test pits. Complete analytical results for discretionary soil samples are presented in Appendix B, Table B-4.

4.1.2.1 Mercury

The highest mercury concentration in subsurface soils from the Site was measured at location TP-17 (34,700 mg/kg), which was collected from a depth of 4–6 ft in the test pit (Figure 4-9). The debris encountered in this test pit included wood, metal scraps, tires, shingles, drums, tar paper, and a white-yellow substance. Concentrations of mercury above the screening criterion (270 mg/kg) were also measured in subsurface soil samples collected from various depths in test pits TP-03 (455 mg/kg), TP-08 (921 mg/kg), TP-13 (690 mg/kg), and TP-19 (983 mg/kg). In contrast, the discretionary samples collected from test pits TP-13 and TP-19 contained low concentrations of mercury (1.7 and 3.9 mg/kg, respectively). The mercury concentrations in all 38 samples collected from the test pits ranged from 0.26 to 34,700 mg/kg, with a mean of 34.9 mg/kg.

Mercury was analyzed in 81 soil intervals collected during the installation of 12 monitoring wells by NJDEP in 1990 (NJDEP 1993a). Soils were analyzed in 2-ft intervals from soil borings that ranged from 14.5 to 20 ft in total depth. The concentration of mercury from all subsurface intervals (> 2 ft) ranged from 0.15 to 1,550 mg/kg (Figure 4-2). Eight samples had mercury concentrations below detection limits. The highest concentration of mercury in any subsurface sample was from the 8- to 10-ft depth at location MW-6 (1,550 mg/kg). The samples with the lowest mercury concentrations were collected from sample intervals generally greater than 12 ft deep. The sample intervals that correspond with sample depths of the subsurface soils collected in this Phase I investigation (approximately 4 to 10 ft) had mercury concentrations that ranged from 0.27 to 1,550 mg/kg.

4.1.2.2 Other Metals

The following distributions were found for metals other than mercury in subsurface soil samples collected from test pits:

- **Arsenic**—Arsenic was detected in all but one subsurface soil sample collected from the test pits. The concentrations of arsenic ranged from 1.4 to 120 mg/kg, with a mean of 9.8 mg/kg. Six samples had concentrations greater than the screening criterion (20 mg/kg). These samples were collected from various depths in test pits TP-01 (21.1 mg/kg), TP-02 (23.3 mg/kg), TP-10 (49.6 mg/kg), TP-14 (32.5 mg/kg), and TP-15 (29.2 and 120 mg/kg).
- **Copper**—Copper was detected in all subsurface soil samples collected from the test pits. Concentrations ranged from 6.73 to 2,190 mg/kg, with a mean of 181 mg/kg. Three samples had concentrations above the screening criterion (600 mg/kg). These samples were collected from various depths in test pits TP-05 (2,190 mg/kg), TP-10 (1,060 mg/kg), and TP-15 (1,030 mg/kg). High concentrations of both arsenic and copper were measured in the sample collected from a depth of 3 to 5 ft in test pit TP-15. A discretionary sample consisting of red pigment material was collected from a depth of 4 ft in this same test pit. This material did not have high concentrations of arsenic or copper, indicating that the red pigment is not the source of elevated arsenic or copper levels.
- **Lead**—Lead was detected in all subsurface soil samples collected from the test pits. Concentrations ranged from 5.9 to 3,830 mg/kg, with a mean of 518 mg/kg. Twenty-four samples had concentrations above the screening criterion (600 mg/kg). The highest concentration of lead (3,830 mg/kg) was measured in the sample collected from a depth of 3 to 5 ft in test pit TP-07. A discretionary sample collected near the surface of TP-07 consisted of a hard white substance, and also had a high concentration of lead (6,020 mg/kg).
- **Thallium**—Thallium was detected in only three subsurface soil samples collected from the test pits. The highest concentration of

thallium (12.9 mg/kg) was measured in a sample collected from a depth of 5.5 to 7.5 ft at TP-05. The two other locations with thallium concentrations above the screening criterion include TP-03 (12.7 mg/kg) and TP-04 (9.4 mg/kg). These samples were all collected from the deepest interval of the test pits in an area of the Site that contains a considerable amount of construction debris. A discretionary sample collected from a depth of 3 ft at TP-05 consisted of a white, pasty substance and had a thallium concentration below the IDL.

- **Zinc**—Zinc was detected in all subsurface soil samples collected from the test pits. The concentration of zinc ranged from 41.5 to 43,200 mg/kg, with a mean of 1,010 mg/kg. Fourteen samples had concentrations greater than the screening criterion (1,500 mg/kg). The highest concentration of zinc was measured in a sample collected from a depth of 4 to 6 ft at TP-17. The highest mercury concentration was also measured in this sample. Samples from the other 13 test pits with zinc concentrations greater than the screening criterion were an order of magnitude lower than the sample collected from TP-17. The zinc concentrations for these locations ranged from 1,790 to 4,960 mg/kg.

4.1.2.3 Semivolatile Organic Compounds

The concentrations of benzo[a]pyrene in subsurface soil samples collected from the test pits ranged from 72 to 49,000 $\mu\text{g/kg}$, with a mean of 539 $\mu\text{g/kg}$. Twelve samples had concentrations below IDLs. Nine had concentrations greater than the screening criterion (660 $\mu\text{g/kg}$). The highest benzo[a]pyrene concentration measured was from the 4- to 6-ft depth at TP-18. The remaining eight samples with concentrations above the screening criterion ranged from 740 to 4,500 $\mu\text{g/kg}$.

Two samples had benzo[b]fluoranthene concentrations above the screening criterion (4,000 $\mu\text{g/kg}$). The highest benzo[b]fluoranthene concentration (84,000 $\mu\text{g/kg}$) was also from the 4- to 6-ft depth at TP-18. The sample collected from TP-14 had a benzo[b]fluoranthene concentration of 7,000 $\mu\text{g/kg}$.

4.1.3 Offsite Surface Soil Analyses

This section summarizes the measured concentrations of SoPCs in surface soils collected from a grid pattern approximately 200×200 ft on the properties adjacent to the north property boundary of the Site. Offsite surface soils are defined as material collected from the 0- to 0.5-ft soil horizon, with rocks and debris removed. A specific chemical indicator list was developed for the offsite soils as discussed in Section 1.4, *Substances of Potential Concern*. Two metals (cadmium and mercury) and six SVOCs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) were identified as SoPCs based on the RDCSCC. Table 4-3 provides a summary of analytical results for SoPCs. Complete analytical results for offsite surface soil samples are presented in Appendix B, Table B-2.

4.1.3.1 Mercury

The highest mercury concentration in offsite surface soils was measured at sample location SS-67 (554 mg/kg), near the corner of Ethel Boulevard and Park Place East (Figure 4-1). The remaining seven samples collected from locations adjacent to the Site (SS-68 through SS-74) had mercury concentrations that ranged from 5.16 to 113 mg/kg, and six of the seven exceeded the RDCSCC (14 mg/kg). All other offsite sample locations, with the exception of SS-63 (16.6 mg/kg), near the middle of the offsite sampling area, had mercury concentrations below the RDCSCC. Two samples had mercury levels below IDLs.

In 1990, NJDEP (1990b) sampled soils to a depth of 7 ft on the property north of the area formerly occupied by the Wood-Ridge POTW (north of offsite sample location SS-58). Mercury was analyzed in samples collected from three depths at six locations. Mercury concentrations in surface soils (0–1 ft) ranged from 1.4 to 21.4 mg/kg. Mercury concentrations in soils from the 3- to 5-ft depth interval ranged from 0.11 to 5.1 mg/kg. Samples from the 6- to 7-ft depth interval were equal to or less than 0.13 mg/kg.

4.1.3.2 Cadmium

A total of seven samples had cadmium concentrations greater than the RDCSCC (1 mg/kg). The cadmium concentrations for these seven samples ranged from 1.11 to 2.98 mg/kg, with a mean of 1.67 mg/kg. The majority of these samples were collected from locations along the grid line adjacent to the Site; two sample locations, SS-55 and SS-59, are located along the east-west grid line farthest from the Site. Concentrations at these locations were 1.39 mg/kg at SS-55 and 2.57 mg/kg at SS-59. The remaining fourteen sample locations had cadmium concentrations ranging from 0.078 to 0.695 mg/kg.

The mean cadmium concentration for all offsite locations is 0.5 mg/kg, which is equal to the geometric mean reported for background cadmium concentrations of New Jersey urban surface soils (Table 4-4). The mean for samples collected from the eight locations adjacent to the Site (0.79 mg/kg) is slightly greater than the mean urban background value, whereas the mean for all offsite locations not adjacent to the Site (0.38 mg/kg) is slightly lower.

4.1.3.3 Semivolatile Organic Compounds

Concentrations where the RDCSCC were exceeded occurred at 8 offsite surface soil locations for benz[a]anthracene (900 µg/kg); 10 locations for benzo[a]pyrene

(660 $\mu\text{g/kg}$); 12 locations for benzo[b]fluoranthene (900 $\mu\text{g/kg}$); 3 locations for benzo[k]fluoranthene (900 $\mu\text{g/kg}$); 3 locations for dibenz[a,h]anthracene (660 $\mu\text{g/kg}$); and 4 locations for indeno[1,2,3-cd]pyrene (900 $\mu\text{g/kg}$). Soil collected at sample location SS-63 had the highest concentrations of all six SVOCs. This sample was collected from a narrow strip of vegetated land between the Winston Corrugated Box Company building and the paved parking lot. Sample locations SS-53 and SS-60 also had concentrations of these six SVOCs that exceeded the RDCSCC. These high concentrations were often associated with samples that contained pieces of asphalt paving material, or with areas that receive runoff from the asphalt parking lots.

These SVOCs are classified as polycyclic aromatic hydrocarbons (PAHs) and are commonly found in urban soils (Bradley *et al.* 1994; Neff *et al.* 1994). The background levels for PAHs in New England urban soils reported by Bradley *et al.* (1994) (Table 4-3) are greater than the mean values of all PAHs presented in Table 4-4 for offsite soils, with the exception of benzo[b]fluoranthene. The mean concentration of benzo[b]fluoranthene in samples collected from locations not adjacent to the Site (1,479 $\mu\text{g/kg}$) is only slightly higher than the arithmetic mean reported by Bradley *et al.* (1994) (1,435 $\mu\text{g/kg}$).

4.2 GROUNDWATER

This section summarizes the measured concentrations of SoPCs in groundwater samples collected from the 12 monitoring wells located in the developed and undeveloped filled areas of the Site. A total of three metals (mercury, iron, and manganese) and three VOCs (benzene, toluene, and xylene) were identified as SoPCs (see Section 1.4). Table 4-5 provides a summary of analytical results for SoPCs. Complete analytical results for groundwater samples are presented in Appendix B, Table B-5.

4.2.1 Mercury

Mercury concentrations in the 12 monitoring well samples ranged from 0.5 to 8.2 $\mu\text{g/L}$, with a mean of 1.16 $\mu\text{g/L}$ (Figure 4-10). Seven of the 12 samples had mercury levels below the IDL (0.2 $\mu\text{g/L}$). Only the sample collected from monitoring well MW-7 had a concentration greater than the groundwater screening criterion (2 $\mu\text{g/L}$). MW-7 is located to the east of the Wolf Warehouse. MW-8, located south of the Wolf Warehouse, had a mercury concentration of 1.2 $\mu\text{g/L}$, and MW-9, located between the two warehouses, had a mercury concentration of 0.5 $\mu\text{g/L}$. The mercury concentration in groundwater from MW-10 was 0.76 $\mu\text{g/L}$. Except at MW-7 and MW-5, all samples collected from monitoring wells in the undeveloped filled area of the Site had mercury concentrations below IDLs. The mercury concentration in groundwater at MW-5 was 0.57 $\mu\text{g/L}$.

Monitoring wells were installed in 1990 and sampled by NJDEP in 1991 (NJDEP 1993a). The groundwater results were reported for total and dissolved (field filtered) metal concentrations (Figure 4-2). (The low-flow sampling technique used in the Phase I field investigation eliminated the need to analyze both filtered and unfiltered groundwater samples.) The concentrations of dissolved metals were generally comparable to the results of the Phase I investigation. Dissolved mercury concentrations for these earlier groundwater samples ranged from 0.32 to 18.7 $\mu\text{g/L}$ in the three samples with concentrations above detection limits. The highest concentration was from MW-3, and the lowest concentration was from MW-10. The concentration reported for MW-7 was 0.44 $\mu\text{g/L}$.

The concentrations of methylmercury in groundwater samples collected during this recent round of sampling ranged from 0.00014 to 0.02 $\mu\text{g/L}$. The highest concentration was from sample location MW-2, and the lowest was from sample location MW-10. Methylmercury was not measured during groundwater sampling in 1991.

4.2.1.1 Other Metals

The following distributions were found for metals other than mercury in groundwater samples collected from the 12 monitoring wells:

- **Iron**—The concentrations of iron in samples collected from monitoring wells ranged from 152 to 37,500 $\mu\text{g/L}$, with a mean of 6,811 $\mu\text{g/L}$. Concentrations greater than the groundwater screening criterion (300 $\mu\text{g/L}$) were measured at all monitoring well locations except MW-9. The highest concentration of iron was from sample location MW-8. Dissolved iron concentrations in samples collected by NJDEP in 1991 ranged from 106 to 33,000 $\mu\text{g/L}$, with a mean of 7,820 $\mu\text{g/L}$ (NJDEP 1993a). The highest concentration was from sample location MW-2. The concentration of iron at sample location MW-8 was 12,500 $\mu\text{g/L}$.
- **Manganese**—The concentrations of manganese in samples collected from the monitoring wells ranged from 74.1 to 3,840 $\mu\text{g/L}$, with a mean of 724 $\mu\text{g/L}$. Concentrations greater than the groundwater screening criterion (50 $\mu\text{g/L}$) were measured at all 12 well locations. The highest concentration of manganese was from sample location MW-6, and the lowest was from MW-9. Dissolved manganese concentrations in samples collected by NJDEP in 1991 ranged from 201 to 7,930 $\mu\text{g/L}$, with a mean of 961 $\mu\text{g/L}$ (NJDEP 1993a). The highest concentration was from sample location MW-9. The dissolved manganese concentration measured at MW-6 was 1,370 $\mu\text{g/L}$.

As discussed further in Section 5.3.1, elevated concentrations of iron and manganese in groundwater are expected in a landfill environment. The concentrations at this Site are well within the range for landfills reported by EPA (1988b), as shown in Table 4-6.

Mean values for this Site are well below the median and average values reported by EPA (1988b). Table 4-6 also shows the composition of landfill leachate reported by others.

4.2.1.2 Volatile Organic Compounds

The SoPCs for volatile organic compounds in groundwater include benzene, toluene, and xylene. Benzene concentrations exceeded the groundwater screening criterion ($1 \mu\text{g/L}$) at sample locations MW-2 ($140 \mu\text{g/L}$) and MW-7 ($18 \mu\text{g/L}$). Benzene was below the IDL ($10 \mu\text{g/L}$) at the remaining 10 sample locations. Toluene and xylene exceeded groundwater screening criteria ($1,000 \mu\text{g/L}$ and $40 \mu\text{g/L}$, respectively) at sample location MW-2 ($1,700 \mu\text{g/L}$ and $390 \mu\text{g/L}$, respectively). The remaining 11 sample locations were below IDLs ($10 \mu\text{g/L}$) for toluene and xylene.

Subsurface soil samples collected from test pit TP-19, in the vicinity of MW-2, had VOC concentrations less than IDLs. No subsurface samples were collected near MW-7; however, surface soil samples collected from this region of the Site also had VOC concentrations below IDLs. The only subsurface samples with benzene, toluene, and xylene concentrations significantly greater than IDLs (see Appendix B, Table B-3) were collected from test pit TP-13. The presence of what appeared to be 5-gal buckets of paint in the test pit could account for these measured concentrations. This test pit is located due south and downgradient of MW-2.

Toluene and xylene were reported during the previous round of groundwater sampling by NJDEP in 1991. The concentrations for toluene were $13 \mu\text{g/L}$ at sample location MW-2, $8 \mu\text{g/L}$ at MW-3, and $2 \mu\text{g/L}$ at MW-4. The only concentration reported for xylene was at sample location MW-2 ($47 \mu\text{g/L}$). No elevated concentrations were reported for benzene (NJDEP 1993a). Although the maximum concentrations were lower than the recent round of sampling, aeration and the resulting volatilization of VOCs during sampling is typically much greater using the conventional groundwater collection methods that were employed in 1991.

4.3 LEACHATE/SEEPS

This section summarizes the measured occurrence of SoPCs in leachate/seep samples collected from five locations. Two samples were collected along the stream banks of the Diamond Shamrock/Henkel ditch (north) (SE-01 and SE-02), and three samples were collected along the stream banks of Berry's Creek (SE-03, SE-04, and SE-06). Seep samples for metals analysis were filtered in the laboratory. The results reported for unfiltered samples will be referred to as total metal concentrations. The results reported for filtered samples will be referred to as the dissolved metal concentration. It should be noted that this concentration represents the dissolved fraction and material (colloidal and particulate) small enough to pass through the filter. This applies to filtered and unfiltered surface-water samples also.

A total of four metals (mercury, cadmium, iron, and manganese) were identified as SoPCs (see Section 1.4). Mercury is not specifically on SoPC for this medium, because the concentrations in the filtered samples were all below the screening criterion ($2 \mu\text{g/L}$). The distributions of mercury and methylmercury are still discussed in this section, because mercury concentrations are greater than surface-water (chronic, freshwater) screening criteria ($0.012 \mu\text{g/L}$). Table 4-7 provides a summary of analytical results for SoPCs and mercury. Complete analytical results for leachate/seep samples are presented in Appendix B, Table B-6.

4.3.1 Mercury

The concentrations of dissolved mercury in seep samples collected from the stream banks of the Diamond Shamrock/Henkel ditch (north) were below the IDL ($0.2 \mu\text{g/L}$) (Figure 4-10). Concentrations of dissolved mercury in seep samples from the stream banks of Berry's Creek were $0.32 \mu\text{g/L}$ at SE-04 and $1.8 \mu\text{g/L}$ at SE-06 (sample SE-03

was $<0.2 \mu\text{g/L}$). Concentrations of total mercury were much greater than dissolved mercury in seep samples (ranging from 2.1 to $104 \mu\text{g/L}$). This increase was a result of the high total suspended solids (TSS) content in the samples (ranged from 140 to 505 mg/L). Too few data are available to develop a correlation between the concentration of total mercury and TSS; however, the highest total mercury concentration is associated with the highest TSS content. The concentration of mercury associated with particulate matter was estimated using these values and ranged from 9.36 to 206 mg/kg.

A similar evaluation was performed for methylmercury. The concentrations of dissolved methylmercury from the two samples collected from the banks of the Diamond Shamrock/Henkel ditch (north) were $0.00011 \mu\text{g/L}$ for location SE-1 and $0.00031 \mu\text{g/L}$ for SE-02. The concentrations of dissolved methylmercury from the banks of Berry's Creek ranged from 0.00028 to $0.00222 \mu\text{g/L}$. The concentrations of total methylmercury in seep samples were substantially higher than dissolved methylmercury, ranging from 0.0074 to $0.0331 \mu\text{g/L}$. This increase was inversely correlated with high TSS load in the samples. The concentration of methylmercury associated with particulate matter for all samples ranged from 0.00125 to 0.221 mg/kg.

4.3.2 Other Metals

The following distributions were found for metals other than mercury in seep samples collected from five sample locations:

- **Cadmium**—The concentration of dissolved cadmium was above the groundwater screening criterion at one sample location ($5.6 \mu\text{g/L}$ at SE-02); the other four samples had dissolved cadmium concentrations below IDLs. The concentration of total cadmium ranged from 3 to $23.3 \mu\text{g/L}$. The highest total cadmium concentration was reported at the same location (SE-01) that had the highest TSS content (505 mg/L). The sample with the highest dissolved cadmium

concentration (5.6 $\mu\text{g/L}$) had only a marginally higher total cadmium concentration (6.9 $\mu\text{g/L}$; TSS of 203 mg/L).

- **Iron**—The concentrations of dissolved iron ranged from 141 to 524 $\mu\text{g/L}$. The only concentration greater than the groundwater screening criterion (>300 $\mu\text{g/L}$) was from seep location SE-04. The concentration for location SE-01 was below the IDL (9.4 $\mu\text{g/L}$). The concentrations of total iron were substantially higher, ranging from 1,430 to 23,600 $\mu\text{g/L}$. The sample with the highest total iron concentration, and also the highest TSS content (505 mg/L), was from sample location SE-01.
- **Manganese**—The concentrations of dissolved manganese were above the groundwater screening criterion (50 $\mu\text{g/L}$) for all seep samples. The dissolved manganese concentrations ranged from 200 to 1,660 $\mu\text{g/L}$, and total manganese concentrations ranged from 295 to 1,770 $\mu\text{g/L}$. The difference between the dissolved and total concentration was not substantial, indicating that manganese in seep samples occurs predominantly in the dissolved phase.

4.4 SURFACE WATER

This section summarizes the measured concentrations of SoPCs in surface waters collected from four locations in Berry's Creek, three locations in the Diamond Shamrock/Henkel ditch (north), and two locations in the onsite basin (Figure 2-1). One surface-water sample was collected during three tidal stages (low, mid, and high) at each location in Berry's Creek. Surface waters from the three locations in the Diamond Shamrock/Henkel ditch (north) were collected as close to high tide as possible. Two surface-water samples were also collected from two locations in the onsite basin. Samples designated for dissolved metals analyses were filtered in the laboratory. A total of two metals (mercury and zinc) were identified as SoPCs for surface water (see Section 1.4). Table 4-8 provides a summary of analytical results for SoPCs in surface water.

Complete analytical results for surface-water samples are presented in Appendix B, Table B-7.

4.4.1 Mercury

Two surface-water locations had concentrations of dissolved mercury above the IDL ($0.2 \mu\text{g/L}$) (Figure 4-11). Both samples were collected during low tide at locations in Berry's Creek ($0.24 \mu\text{g/L}$ at SW-02, and $0.2 \mu\text{g/L}$ at SW-03). The remaining samples from locations SW-01 and SW-04 collected during low tide were below the IDL. All dissolved surface-water concentrations in samples collected from the onsite basin, the Diamond Shamrock/Henkel ditch (north), and during high and mid-tide in Berry's Creek were less than the IDL. The IDL for mercury is greater than the surface-water (chronic) criterion used to screen the data during the SoPC selection process. These concentrations are, however, a factor of ten less than the surface-water (acute) criterion ($2.1 \mu\text{g/L}$) for dissolved mercury.

The concentrations of total mercury ranged from 0.74 to $17.6 \mu\text{g/L}$. The highest concentration was from sample location SW-08, collected from the onsite basin. The difference in dissolved and total mercury concentrations cannot be attributed solely to the TSS content in the sample. Rather, this difference is a combination of the amount of suspended solids in the water column and the concentration of mercury associated with these suspended solids and with the underlying sediment. This relation was most apparent in the samples collected from the onsite basin. The TSS contents in samples SW-08 and SW-09 were relatively low (6 mg/L), yet the total mercury concentrations were high compared with the dissolved concentrations. The concentrations of mercury associated with particles calculated for onsite basin samples are $2,900 \text{ mg/kg}$ for SW-08 and 933 mg/kg for SW-09. These values are similar to the corresponding sediment concentrations from these locations ($1,184 \text{ mg/kg}$ at SD-08 and 856 mg/kg SD-09, for the 0- to 2-cm depth interval).

The concentrations of dissolved methylmercury in Berry's Creek samples ranged from 0.00008 to 0.00047 $\mu\text{g/L}$. Concentrations for the two samples collected from the onsite basin were 0.00085 $\mu\text{g/L}$ for SW-08 and 0.00098 $\mu\text{g/L}$ for SW-09. The dissolved methylmercury concentrations from the Diamond Shamrock/Henkel ditch (north) samples ranged from 0.00019 to 0.00027 $\mu\text{g/L}$.

The concentration of total methylmercury ranged from 0.00058 to 0.00464 $\mu\text{g/L}$. The concentrations of total methylmercury in Berry's Creek samples were higher in samples collected during low tide (0.00105 to 0.00287 $\mu\text{g/L}$) than in those collected during high and mid-tide (0.00058 to 0.00095 $\mu\text{g/L}$). The sample with the largest difference between the dissolved and total methylmercury concentrations was collected at sample location SW-05, which also had the highest TSS content (84 mg/L). The two samples from the onsite basin had similar total methylmercury concentrations (0.00218 $\mu\text{g/L}$ at SW-08 and 0.00233 $\mu\text{g/L}$ at SW-09).

4.4.2 Other Metals

The following distributions were found for zinc in filtered and unfiltered surface-water samples collected from nine locations:

- **Zinc**—All sample locations except SW-05 (531 $\mu\text{g/L}$) had dissolved zinc concentrations below the screening criterion (100 $\mu\text{g/L}$). The concentrations of dissolved zinc, excluding SW-05, ranged from 27.7 to 76.0 $\mu\text{g/L}$ (three samples were below IDLs). The concentrations of total zinc, except SW-05, were only marginally greater than these filtered samples, ranging from 31.7 to 88.8 $\mu\text{g/L}$. The total zinc concentration in sample SW-05 was 5,680 $\mu\text{g/L}$, and this large increase is most likely related to the high TSS content in the sample (84 mg/L).

4.5 SEDIMENT

Surface sediment was collected from each surface-water location. Surface sediment is defined as the upper 0 to 15 cm of sediment. A second grab sample was collected from the upper 0 to 2 cm at each sample location and analyzed only for mercury. A total of nine metals (mercury, arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc), eleven SVOCs (anthracene, benz[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, indeno[1,2,3-cd]pyrene, phenanthrene, and pyrene), and two PCB Aroclor® mixtures (1248 and 1260) were identified as SoPCs (see Section 1.4). Table 4-9 provides a summary of analytical results for SoPCs in sediment. Complete analytical results for sediment samples are presented in Appendix B, Table B-8.

4.5.1 Mercury

The mercury concentrations for surface sediment collected from the 0- to 15-cm sampling interval ranged from 33.8 to 1,290 mg/kg (Figure 4-11). The mercury concentrations for samples from the Diamond Shamrock/Henkel ditch (north) ranged from 59.2 to 69.6 mg/kg. The sediment samples collected from the onsite basin had mercury concentrations of 1,290 mg/kg (SD-08) and 1,280 mg/kg (SD-09). The only sample below the screening criterion (0.2 mg/kg) was from the most downstream location in Berry's Creek (SD-04) that was also below the IDL (0.16 mg/kg). The remaining three samples collected from Berry's Creek ranged from 33.8 to 70 mg/kg.

A second sediment sample was collected from the 0- to 2-cm depth at each sample location to evaluate the mercury concentration in the aerobic sediment. The mercury concentrations in these 2-cm intervals varied little from the 15-cm intervals at most locations. The three samples from the Diamond Shamrock/Henkel ditch (north) ranged from 57.2 to 97.8 mg/kg. The mercury concentrations in the onsite basin samples were

slightly lower than the 15-cm sample intervals, at 1,180 mg/kg for SD-08 and 856 mg/kg for SD-09. The largest discrepancy between the two sampling intervals occurred at location SD-02. The mercury concentration increased from 69.6 mg/kg in the 15-cm sample interval to 11,100 mg/kg in the 2-cm sample interval. No increase was observed at sample location SD-01 (31.3 mg/kg), and only a marginal increase was observed at locations SD-03 (223 mg/kg) and SD-04 (0.89 mg/kg).

The concentrations of methylmercury in surface sediments collected from the 0- to 15-cm sample intervals ranged from 0.00038 to 0.126 mg/kg. The highest concentrations of methylmercury were measured in sediment samples from the onsite basin (0.126 mg/kg at SD-08 and 0.0982 at SD-09). The lowest concentrations of methylmercury were observed in the sediment from Berry's Creek (0.00038 to 0.00975 mg/kg). The methylmercury concentrations in the Diamond Shamrock/Henkel ditch (north) ranged from 0.012 to 0.02 mg/kg.

4.5.2 Other Metals

The following distributions were found for metals other than mercury in surface sediment from the 0- to 15-cm interval at nine sample locations:

- **Arsenic**—The arsenic concentrations at sample locations in the Diamond Shamrock/Henkel ditch (north) ranged from 16.8 to 24.6 mg/kg. The samples from the onsite basin had arsenic concentrations of 3.6 mg/kg at SD-08 and 8.8 mg/kg at SD-09. The concentrations of arsenic in surface sediment from Berry's Creek ranged from 6.6 to 9.1 mg/kg. All sample locations except SD-08 had arsenic concentrations greater than the screening criterion (6 mg/kg).
- **Cadmium**—The cadmium concentrations at sample locations in the Diamond Shamrock/Henkel ditch (north) ranged from 12.1 to 17.1 mg/kg. The samples from the onsite basin had cadmium

concentrations of 0.89 mg/kg at SD-08 and 1.6 mg/kg at SD-09. The concentrations of cadmium in surface sediment from Berry's Creek ranged from 6.8 to 13.8 mg/kg. Sample location SD-04 was less than the IDL (0.07 mg/kg) and the only sample below the screening criterion (0.6 mg/kg).

- **Chromium**—The chromium concentrations at sample locations in the Diamond Shamrock/Henkel ditch (north) ranged from 294 to 930 mg/kg. The samples from the onsite basin had chromium concentrations of 55.4 mg/kg at SD-08 and 65.6 mg/kg at SD-09. The concentrations of chromium in surface sediment from Berry's Creek ranged from 18 to 265 mg/kg. All sample locations, except SD-04, had chromium concentrations greater than the screening criterion (26 mg/kg).
- **Copper**—The copper concentrations at sample locations in the Diamond Shamrock/Henkel ditch (north) ranged from 190 to 287 mg/kg. The samples from the onsite basin had copper concentrations of 93.7 mg/kg at SD-08 and 136 mg/kg at SD-09. The concentrations of copper in surface sediment from Berry's Creek ranged from 11.1 to 161 mg/kg. All sample locations, except SD-04, had copper concentrations greater than the screening criterion (16 mg/kg).
- **Lead**—The lead concentrations at sample locations in the Diamond Shamrock/Henkel ditch (north) ranged from 177 to 232 mg/kg. The samples from the onsite basin had lead concentrations of 188 mg/kg at SD-08 and 469 mg/kg at SD-09. The concentrations of lead in surface sediment from Berry's Creek ranged from 20.5 to 176 mg/kg. All sample locations, except SD-04, had lead concentrations greater than the screening criterion (31 mg/kg).

- **Nickel**—The nickel concentrations at sample locations in the Diamond Shamrock/Henkel ditch (north) ranged from 37.8 to 66.4 mg/kg. The samples from the onsite basin had nickel concentrations of 14.3 mg/kg at SD-08 and 28.1 mg/kg at SD-09. The concentrations of nickel in surface sediment from Berry's Creek ranged from 14.8 to 31.2 mg/kg. The concentration of nickel exceeded the screening criterion (16 mg/kg) at seven sample locations.
- **Silver**—The silver concentrations at sample locations in the Diamond Shamrock/Henkel ditch (north) ranged from 2.3 to 4.8 mg/kg. The samples from the onsite basin had silver concentrations of 1.3 mg/kg at SD-08 and 2.4 mg/kg at SD-09. The concentrations of silver in surface sediment from Berry's Creek ranged from 1.4 to 3.6 mg/kg. Sample location SD-04 was less than the IDL (0.58 mg/kg) and the only sample location below the screening criterion (1 mg/kg).
- **Zinc**—The zinc concentrations at sample locations in the Diamond Shamrock/Henkel ditch (north) ranged from 2,640 to 7,300 mg/kg. The samples from the onsite basin had zinc concentrations of 556 mg/kg at SD-08 and 844 mg/kg at SD-09. The concentrations of zinc in surface sediment from Berry's Creek ranged from 56.1 to 792 mg/kg. All sample locations, except SD-04, had zinc concentrations greater than the screening criterion (120 mg/kg)

4.5.3 Semivolatile Organic Compounds

The individual concentrations for the eleven SVOCs identified as SoPCs are presented in Table 4-9. These SVOCs are classified as PAHs and were ubiquitous throughout all sediment samples collected during this investigation. Sample location SD-05 had the highest total concentration of the SVOCs listed in Table 4-9, although SD-01 had elevated IDLs that were higher than the measured concentration at SD-05. Total

concentrations decreased with greater distance downstream from SD-05 along the Diamond Shamrock/Henkel ditch (north). The sample collected from the eastern side of the onsite basin (SD-09) had higher concentrations of SVOCs than the sample from the western side of the basin (SD-08).

4.5.4 PCB Aroclors°

The concentrations of Aroclor® 1248 in surface sediment ranged from 190 to 4700 $\mu\text{g/kg}$. The screening criterion (30 $\mu\text{g/kg}$) was exceeded in samples from seven of the nine sample locations. Two locations in Berry's Creek (SD-01 and SD-04) had concentrations below IDLs (33 $\mu\text{g/kg}$). The lowest concentrations were measured in samples from the onsite basin (240 $\mu\text{g/kg}$ at SD-08 and 190 $\mu\text{g/kg}$ at SD-09). The concentrations of Aroclor® 1248 in the Diamond Shamrock/Henkel ditch (north) ranged from 1,400 to 4,700 $\mu\text{g/kg}$.

The concentrations of Aroclor® 1260 in surface sediment ranged from 260 to 490 $\mu\text{g/kg}$. The screening criterion (5 $\mu\text{g/kg}$) was exceeded in samples from four of the nine sample locations. Five locations—three in Berry's Creek and two in the Diamond Shamrock/Henkel ditch (north)—were below IDLs. The Aroclor® 1260 concentrations measured in onsite basin samples were 490 $\mu\text{g/kg}$ at SD-08 and 260 $\mu\text{g/kg}$ at SD-09.

4.6 AIR SAMPLING

Air samples were collected on two separate occasions during the field investigation. Particulate mercury and total gaseous mercury were measured in five samples collected in September and October of 1997. Total gaseous mercury was measured in six samples collected in March 1998. Particulate mercury is defined as particles 0.1 μm in size or larger. Complete analytical results for air samples are presented in Appendix B, Table

B-9. The daily meteorologic conditions for dates of air sampling were obtained from nearby Teterboro Airport and can be found in Appendix J.

The concentrations of particulate mercury ranged from 0.10 to 1.66 ng/m³ (Figure 4-12). The highest concentration was measured in the Wolf Warehouse. The lowest mercury particulate levels were measured in the U.S. Life Warehouse and at a location between the two warehouses. Gaseous mercury sampling was conducted concurrently with the particulate mercury sampling. Gaseous mercury concentrations ranged from 1.42 to 60.6 ng/m³. The highest concentration was measured within the undeveloped filled area, at sample location A-4, and the lowest was measured at the selected Site background location A-3.

Gaseous mercury measurements were made around the perimeter of the undeveloped filled area over the duration of the trenching activities. Gaseous mercury concentrations ranged from 2.85 to 14.43 ng/m³. The highest concentration was measured near the gate entrance to the undeveloped filled area at location B-3; the lowest was measured near the southern corner of the undeveloped filled area at location B-6.

The NJDEP (1991) conducted two rounds of air sampling in the vicinity of the Site. The first round was conducted on June 30, 1989. The second round was conducted on October 29, 1990. Particulate and gaseous mercury samples were collected from six locations in the vicinity of the Site (only three samples were within the Site boundaries) and one background location. Only one gaseous mercury sample, located near the gate entrance to the undeveloped filled area, had a concentration (720 ng/m³) above detection limits. This concentration is an order of magnitude greater than gaseous mercury concentrations measured during the recent round of sampling and may reflect the variability in mercury concentrations inherent in the type of sorbent used, rather than the actual ambient air concentration.

The time-weighted (10 hour) average exposure limit recommended by the National Institute for Occupational Safety and Health (1997) is 50 µg/m³ for gaseous mercury.

The highest concentration of gaseous mercury measured during the recent round of sampling (60.6 ng/m^3) is approximately 1,000 times less than this exposure limit. The New Jersey indoor air criteria value for mercury is 300 ng/m^3 , which is six times greater than the highest measured value on Site (24 N.J.R. 386).

4.7 HAZARDOUS SUBSTANCE INVENTORY

As part of the hazardous substance inventory conducted in conjunction with the trenching activities, six drums and four samples from the ground surface were collected. Sample locations were selected based on observations made during trenching activities, and on a Site walk along the 100×100-ft control grid. A summary of analytical results is presented in Appendix B, Table B-10. In addition, nine discretionary soil samples were collected from the test pits. Although considered part of the subsurface soil sampling program (see Section 2.2.3), these samples were also collected from locations in the trenches with obvious discoloration or waste deposits. A summary of analytical results for the discretionary samples is presented in Appendix B, Table B-4.

All hazardous substance samples were analyzed for TAL metals, and the results were screened against the NRDCSCC. Five of the eleven metals identified as Site SoPCs had concentrations that exceeded the screening criteria. The samples collected from the three drums exhumed from the test pits did not have metals concentrations above the screening criteria. Of the three surface drums sampled, the sample from location HS-4 had an arsenic concentration (29.1 mg/kg) greater than the screening criterion (20 mg/kg). The sample from location HS-7 had a mercury concentration ($3,550 \text{ mg/kg}$) greater than the screening criterion (270 mg/kg). Three of the four surface samples collected during the Site walk-through had metals concentrations that exceeded the screening criteria. Lead and thallium exceeded the screening criteria (600 and 2 mg/kg , respectively) at sample location HS-6. The highest concentration of mercury measured on the Site ($295,000 \text{ mg/kg}$) was from sample location HS-5. Samples collected from locations HS-2 and HS-5 exceeded the screening criterion for zinc ($1,500 \text{ mg/kg}$).

Four metals exceeded the screening criteria in the discretionary samples collected from the test pits. Samples collected from locations TP-5 and TP-7 had arsenic concentrations (21.3 and 23.4 mg/kg, respectively) just slightly above the screening criterion (20 mg/kg). The concentrations of copper in samples from location TP-7 (10,500 mg/kg) and TP-19 (8,720 mg/kg) exceeded the screening criterion (600 mg/kg). Lead concentrations were elevated above the screening criterion (600 mg/kg) in samples collected from locations TP-7 (816 and 6,020 mg/kg), TP-13 (58,200 mg/kg), and TP-19 (672 mg/kg). Zinc concentrations in samples collected from locations TP-7 (2,060 and 7,980 mg/kg) and TP-19 (9,040 mg/kg) exceeded the screening criterion (1,500 mg/kg).

No VOCs or SVOCs exceeded the NRDCSCC in the samples collected from the three drums exhumed from the test pits. Samples collected from the three surface drums, the ground surface, and discretionary samples were not analyzed for VOCs or SVOCs.

4.8 CHEMICAL DATA QUALITY ASSESSMENT

A quality assurance review of the chemical analysis results was performed by an independent reviewer retained by Exponent. Data validation procedures and qualifier assignments were completed according to EPA national functional guidelines for evaluating inorganic and organic analyses, as applicable (U.S. EPA 1994a,b). Data validation was completed to EPA Level III specifications (U.S. EPA 1995b). The procedures and results of the quality assurance review, in addition to laboratory case narratives and nonconformance summaries, are presented in Appendix M. The results from the quality control samples collected in the field, including sample duplicates, equipment rinsate blanks, and trip blanks (for VOCs only), are presented in Appendix L.

This overall program review indicated that the data quality objectives identified in the QAPP (PTI 1997) for this Phase I investigation were met. Some quality issues, however, were noted by the data quality reviewer and are discussed in the quality assurance review

summary presented in Appendix M. In summary, several TAL metals were detected in the initial and continuing calibration blanks above the applicable action limits, which resulted in approximately 13 percent of the samples being restated as undetected by the reviewer. Method and equipment rinsate blanks at concentrations above applicable action limits for VOC and SVOC analyses resulted in less than 1 percent of samples being restated as undetected. Qualifiers assigned to undetected values during the review process are labeled as "U" in the data tables presented in Appendix B and can be distinguished from the laboratory qualifiers that are labeled as "u."

Problems with accuracy and precision, including calibration and internal standards, and recoveries of matrix spikes, surrogate compounds, outside the control limits, resulted in approximately 10 percent of the samples being restated by the reviewer as estimated (J).

In accordance with the Work Plan, NJDEP will be validating a subset of the laboratory analytical results.

5.0 TRANSPORT AND FATE OF SoPCs

The purpose of this section is to characterize the transport and fate processes that produced the current distribution of SoPCs in the environment at the Ventron/Velsicol Site and that may alter their distribution in the future. These processes need to be characterized at a level sufficient to support risk management decisions such as those that will be associated with the feasibility study.

Transport and fate of substances in the environment refers to movement of substances in the environment and alterations of those substances during that movement. Transport processes can include movement of free-phase substances and movement of the environmental media (such as water, soil, sediment, or air) with which the substances are associated. These processes can also include transfers between different environmental media, such as the partitioning of substances between the dissolved and solid phases in water. Substance alterations in the environment occur through many different processes. Examples of particular importance for the Site are the transformations of mercury between different forms, especially between inorganic and organic forms, as in the methylation and demethylation of mercury and the formation of various inorganic mercurial species, such as mercuric sulfide. The fate of a substance fate refers to its location in the environment and the state in which it eventually exists. For all transport and fate pathways, the behavior of a specific SoPC depends on the physical motion of the medium with which the SoPC is associated, the physical/chemical properties of that medium, and the physical/chemical properties of the SoPC itself.

Section 5.1 discusses potential fate and transport pathways and issues of relevance to SoPCs at the Site, principally the physical motion and physical/chemical properties of the environmental media as they influence SoPC transport and fate. Based on the analysis in Section 5.1, those pathways that are most relevant for this Site are discussed further in subsequent sections. The subsequent sections, 5.2 through 5.5, discuss the medium-

specific behavior of mercury, the other metal SoPCs, the SVOC and PCB SoPCs, and the VOC SoPCs for the selected pathways.

5.1 POTENTIAL MIGRATION PATHWAYS

Each of the three distinct areas of the Site (developed area, undeveloped filled area, and marsh area) was treated as a potential source area for migration, either off of the Site or to another of the three areas of the Site. SoPC concentration differences within each area, and the potential for migration within any of the areas, are of less significance than the potential for migration away from each area. Migration within each of these three areas, therefore, will be evaluated only to the extent that it influences potential migration away from the area.

Potential migration pathways from these areas include migration in groundwater and air (volatilization only) from the developed area; and migration in groundwater, air (volatilization and fugitive particulates), and surface water (dissolved SoPCs and through soil erosion) from the undeveloped filled area. The marsh area was considered both as a potential source of SoPCs to offsite areas (Berry's Creek, the Diamond Shamrock/Henkel ditch (south), and Never Touch Creek) and as a potential sink for SoPCs from offsite areas. During tidal flooding of the marsh, some sediment from offsite may be deposited in the marsh area, and some sediment from the marsh may be eroded and carried away. There may also be transport of dissolved SoPCs both to and from the marsh area.

Identified SoPC sources at the Site are residuals from past activities. Introduction of new SoPCs to the Site from the WRCC facility had ended by 1974, as had placement of materials into the undeveloped filled area. With the remediation of the Diamond Shamrock/Henkel property, active contributions from offsite sources, except for migration in environmental media, would also have ended.

Section 5.1 discusses the potential significance of all of these potential pathways in relation to the identified sources. Based on this evaluation (presented below in Section 5.1), the following were selected for further evaluation in Sections 5.2 through 5.5.

- **Developed area**
 - Soil contamination as a potential source of groundwater contamination
 - Soil contamination as a potential source of volatilization to the air (mercury only)

- **Undeveloped filled area**
 - Soil contamination as a potential source of groundwater contamination
 - Soil contamination as a potential source of volatilization and fugitive dust to the air (mercury only)
 - Groundwater contamination as a potential source of surface-water and sediment contamination
 - Bank seeps as a potential source of surface-water and sediment contamination

- **Marsh Area**
 - Discussion of surface-water and sediment issues as described below.

Surface Water—The relation of surface-water concentrations to Site groundwater and seep concentrations is discussed in a qualitative manner. The factors that control the transport and fate of SoPCs in surface-water bodies are also discussed. Quantitative evaluation of these relations, however, is beyond the scope of this RI/FS, and in any

event, would be extremely difficult. Any potential contributions from the Site to surface water are rapidly diluted and transported ~~due to~~ tidal water movement. Further, in addition to the Site, there are many other potential sources of SoPCs to the surface-water bodies adjacent to the Site. Assessment of these other sources and the relative contributions from the Site are beyond the scope of this RI/FS. These issues, which may be addressed in the basin-wide RI/FS for Berry's Creek, limit the extent to which surface-water data can be used to draw conclusions regarding any continuing contributions from the Site.

Sediment—The distribution of SoPCs in sediment, as it relates to potential migration from the Site, and the potential impact on surface water-quality, is discussed. Quantitative evaluation of this relation, however, is beyond the scope of this RI/FS. As with surface water, this relation would be extremely difficult to quantify. In general, sediments are a sink for SoPCs that enter the surface-water bodies. Sediment transport processes, however, especially in tidal systems where the principal flow direction reverses on a recurring basis, tend to obscure any patterns that would allow specific contributions from the Site to be assessed. Further, as described above for surface water, the Site is only one of many potential contributors of SoPCs to sediments. Assessment of the relative contributions of the many potential sources is beyond the scope of this RI/FS. These issues, which may be addressed during the basin-wide RI/FS for Berry's Creek, limit the extent to which sediment data can be used to draw conclusions regarding any continuing contributions from the Site.

The rationale for selecting the pathways which were given further consideration is discussed below.

5.1.1 Soil, Groundwater, and Seeps

Soils—Soils were considered as part of potential SoPC migration pathways either directly, through erosion by water or air, or indirectly, through leaching of SoPCs into

groundwater. Of these two pathways, Site soils were evaluated further only with respect to the potential for leaching from soil to groundwater. After leaching into groundwater, SoPCs can migrate with the groundwater. The SoPC migration rates, however, are generally slower than groundwater migration rates because of the tendency for the SoPCs to adsorb to solids. *On contrary, Soil might be satid*

Surface soil erosion by water or air from the developed and undeveloped filled areas was not expected to be a primary migration pathway at this Site because of the surface cover. The developed area is entirely paved or covered with trap rock (for the railroad bed), and the undeveloped filled area is heavily vegetated. Further, no areas of soil erosion were noted during the field studies. These sources of soil erosion, therefore, will not be discussed further in Sections 5.2 through 5.5

The creek and ditch banks, however, are potential sources of soil erosion into Berry's Creek and the Diamond Shamrock/Henkel ditches. Also, in the marsh area, the soil/sediment are subject to resuspension due to tidal water movement and periods of flooding. The thick cover of common reed and associated dense root mat, however, minimizes soil/sediment resuspension from the marsh area. The creek and ditch banks and marsh area are among the many potential sources of suspended sediment and SoPCs to the surface-water bodies in the Berry's Creek basin. SoPC concentrations in surface-water samples (unfiltered and filtered) reflect contributions from all sources, not only the Ventron/Velsicol Site. Identification of among the many various sources of contaminated suspended solids in surface waters, however, is not part of the scope for this RI/FS.

Groundwater Hydrology—There are no known current or anticipated future uses of groundwater at, adjacent to, or downgradient of the Site. The key groundwater issue at this Site, therefore, is the potential for migration of SoPCs in groundwater from the Site to the adjacent surface-water bodies at concentrations high enough to be of potential significance with respect to surface-water quality. A screening process for determining which SoPCs have this potential is described in Section 5.1.4. Nevertheless, since allowable uses under the current site area groundwater classification of II-A (see Section

3.6) include potable water supply, evaluation of the potential for leaching to and migration in groundwater, with respect to groundwater quality on the Site, is also discussed in this section.

Each of the three distinct areas of the Site has a unique hydrologic and geochemical regime that will control the transport and fate of SoPCs. Section 3 discussed the Site hydrology in detail, and key issues are summarized here. Groundwater geochemistry is discussed below under the groundwater geochemistry heading.

At this Site, the groundwater surface (piezometric surface) is generally shallow (less than 10 ft bgs), and near-surface groundwater is expected to discharge principally to Berry's Creek and the Diamond Shamrock/Henkel ditch (north). Some Site groundwater also may discharge directly to the marsh area of the Site. The developed area is almost completely paved, limiting the opportunity for infiltration of rain or surface runoff to groundwater. In the undeveloped filled area, the potential for infiltration is greater than in the surrounding areas, which creates the groundwater mounding and associated radial flow pattern in this area. In addition to the radial flow pattern, there is likely a downward flow component near the center of the area, which then turns upward as the flow approaches the discharge areas.

As discussed in Section 3, the marsh area is expected to be an area of local and regional groundwater discharge. The entire Site was likely an area of groundwater discharge before it was filled. As portions of the Site became filled, they became local recharge areas. In the marsh, tidal cycles are expected to have a short-term influence on the discharge rate into the marsh over a tidal cycle, with discharge slowed during high tide and accelerated during low tide. The longer-term regional hydraulics and the mean water level in the marsh, however, govern the average discharge rate into the marsh.

Groundwater Geochemistry—The field measurements shown in Table 5-1 show that groundwater on the Site has generally low dissolved oxygen content (i.e., is anoxic) and negative oxidation-reduction potential values. The highest value of dissolved oxygen

was 1.25 mg/L, and most values were well below 1 mg/L. The oxidation-reduction potential values were all negative, except for the most upgradient well (MW-10). This indicates that the reducing conditions most likely are created as the groundwater moves under the Site. Geochemical conditions represented by these parameters can have a strong impact on the behavior of metals in groundwater. For example, under these reducing conditions, iron and manganese tend to transform into soluble forms, enhancing their mobility in groundwater. Several metals form insoluble complexes with sulfides—notably for this Site, cadmium, copper, lead, mercury, nickel, silver, zinc, and to a lesser extent, arsenic—reducing their mobility in groundwater.

The available data do not include direct measurements of sulfides, but do indicate that sulfides may be present in groundwater. Sulfate was measured and is present in the groundwater in the developed area. Under reducing conditions, bacterial sulfate reduction may produce sulfides. Sulfate concentrations range from 8 to 42 mg/L in developed-area wells. Sulfate was below the IDL, but with an elevated IDL of 40 mg/L, in MW-9. Sulfate concentrations were below the IDL of 5 mg/L in wells MW-1, MW-4, and MW-5, but ranged from 30 to 730 mg/L in the other undeveloped-filled-area wells. The sulfate concentrations in wells MW-3 and MW-12 were significantly higher than in the other wells. These higher concentrations may be related to the inorganic sludge that was deposited on the Site and consists mainly of calcium sulfate (July 26, 1962 letter from John Bratt to Hans Rahm).

Throughout the Site, the underlying organic-rich marsh soils (commonly known as meadow mat) are expected to serve as a barrier to potential downward migration of dissolved VOCs, SVOCs, and mercury, because these substances will sorb to the organic material in this soil layer. The meadow mat may also deplete oxygen through the decay of organic matter, which would contribute to the reducing conditions in the groundwater.

In the developed area, the pavement is expected to reduce infiltration of air, compared to an unpaved surface, potentially contributing to the chemically reduced conditions in the groundwater beneath this area.

In the undeveloped filled area, decomposition of the organic material in the fill may contribute to the anoxic reducing groundwater conditions. Groundwater in this area does not, however, have the elevated values of BOD, COD, and alkalinity typical of municipal landfill leachate (see Table 4-6 for typical landfill leachate values). This may indicate that the materials deposited on this Site have relatively low putrescible organic matter content, compared to typical municipal landfills. These data are consistent with both the observation of materials in the test pits (see Section 3.4.2 and Appendix D) and the restriction on dumping household garbage in the agreement that allowed the Borough of Wood-Ridge to dump other refuse on the Site (Attachment A to the BITM, Volume 3). In the undeveloped filled portion of the site, infiltration—and thus the potential leaching of contaminants to groundwater—is expected to be greater than in the developed area. Also, as mentioned above, the meadow mat beneath the fill is expected to significantly attenuate potential downward migration of SoPCs, especially SVOCs, VOCs, and mercury.

In the marsh area, the discharging groundwater may also be highly reducing, because the immediately upgradient groundwater is reducing, and decay of the abundant soil organic material in the marsh would consume oxygen. The field teams noted hydrogen sulfide odors in the marsh, indicating the presence both of sulfides and of highly reducing conditions. Such conditions are common in marsh areas. In addition to naturally occurring sulfur, sulfur may have been released to the Site in the form of calcium sulfate sludge (July 26, 1962 letter from John Bratt to Hans Rahm). Reducing conditions at the Site may lead to conversion of sulfate to sulfide by sulfate-reducing bacteria.

Burping?

Seeps—Dissolved SoPC concentrations in seeps provide a qualitative indication of the potential for net migration of SoPCs from the undeveloped filled area to the adjacent surface-water bodies. When dissolved SoPC concentrations in seep samples are higher than surface-water concentrations (excluding samples taken at low tide), the concentration difference may reflect net migration from the Site to the adjacent surface-water bodies. Quantitative evaluation of net migration rates is not needed to support

evaluation of remedies contemplated for the Site at this time (see Section 8.4), and in any event, would be extremely difficult.

The significance of any net migration from the Site could not be determined by considering only contributions from this Site, because there are many potential sources of SoPCs to Berry's Creek. However, SoPCs may be identified that have the potential to migrate from the undeveloped area to the adjacent surface-water bodies at concentrations of significance with respect to surface-water quality. A screening process to evaluate this possibility is described in Section 5.1.4.

Seeps are likely to consist of a blend of surface water exfiltrating from the bank and groundwater discharging from the Site. As the water level in Berry's Creek and the Diamond Shamrock/Henkel Ditch (north) rises and falls during tidal cycles, water infiltrates into the Creek and ditch banks when the water level is high and exfiltrates from the banks when the water level is low. Over time, the amount of water that infiltrates should be approximately equal to the amount that exfiltrates. Additionally, groundwater is discharging to Berry's Creek and the Diamond Shamrock/Henkel ditch (north), creating a net outflow of water from the undeveloped filled area to the adjacent surface-water bodies.

For the portion of the seep water that is exfiltrating surface water, the dissolved SoPC concentrations reflect both concentrations in the surface water that infiltrated the bank and changes to those concentrations (either increases or decreases) caused by contact with the Site soils. Some suspended solids may also be carried with the infiltrating water. All but the smallest suspended solids, however, would be expected to be filtered out rapidly as the water infiltrates. For the portion of the seep that is discharging groundwater, the SoPC concentrations reflect net migration from the Site. As discussed in Section 4.3, only the dissolved concentrations, from the filtered seep samples, were used to evaluate the transport of SoPCs. The unfiltered seep samples contain particulate matter that may have come from surface sediments introduced during sampling.

5.1.2 Surface Water and Sediment

SoPCs, including mercury, in surface-water and sediment samples from Berry's Creek and the Diamond Shamrock/Henkel ditch (north) could be from any of several potential sources, including prior or continuing SoPC releases from the Site, and prior or continuing releases from other potential sources in the Berry's Creek basin. Prior releases may be bound in sediments and have the potential to influence surface-water quality through sediment/water interactions. Similarly, methylmercury in surface water could be present due either to methylation of mercury in the surface water or sediment or to migration of methylmercury from the Site or other sources, with subsequent dilution and possible demethylation in the surface water. The potential transport and fate mechanisms related to the Site are discussed below and in subsequent parts of Section 5.

SoPCs may migrate off site in surface water, either through distributed surface runoff from the undeveloped filled area or marsh, or through surface-water drainage features such as Diamond Shamrock/Henkel ditches, the drainage ditch in the center of the marsh area, or Berry's Creek. In both pathways, the SoPCs may be either dissolved in the water or attached to solid materials carried by the water. The fate and transport of SoPCs in surface water, therefore, is governed by the motion of the water and the tendency for SoPCs to associate with particulate matter in the water.

SoPCs associated with particulate matter eventually become part of the sediment. Sediment transport and fate is governed by the hydrodynamics of the water body and the sediment characteristics, such as particle size and cohesion, that influence resuspension and settling rates.

This Phase I remedial investigation scope does not include evaluation of flow regimes or sediment transport characteristics of surface-water bodies. These issues may be addressed during the basin-wide RI/FS for Berry's Creek. The fate and transport discussion in this report, therefore, focuses on the relative tendency for SoPCs to

associate with particulate matter, the geochemical characteristics that control those tendencies, and the observed relation between sediment and surface-water SoPC concentrations.

Distributed surface runoff is not expected to be a significant issue at this Site. In the developed area, the pavement prevents contact between rain and SoPCs in the soil. [In the undeveloped filled area, infiltration rates are likely to be high enough that negligible surface runoff reaches Berry's Creek or the Diamond Shamrock/Henkel ditch (north). In the marsh area, tidal water movement is likely to dominate non-tidal surface runoff.] *groundwork* Direct surface runoff to surface-water bodies, therefore, will not be discussed further.

Water in the onsite basin most likely includes some surface runoff and may also include contributions from groundwater. The ground surface elevation at the perimeter of the basin is within one foot of the groundwater surface elevation shown in Figure 3-2, indicating that the basin may be in hydraulic communication with the groundwater. After storm events, when the basin receives surface runoff, therefore, the basin may recharge the groundwater, and between storm events, groundwater may recharge the basin.

5.1.3 Air

SoPCs can enter the air through volatilization (in the case of volatile substances such as elemental mercury) or through suspension of dust particles that contain SoPCs. [As mentioned in Section 5.1.1, however, the Site is not expected to generate appreciable amounts of fugitive dust because of the surface cover—pavement in the developed area, thick vegetation in the undeveloped filled area, and a combination of thick vegetation and water in the marsh.] Volatilization is a potential pathway of migration for SoPCs. Other than mercury, however, the only SoPCs with appreciable potential for migration via volatilization are the VOCs. (The VOC SoPCs were found in only a few areas of the site and were not found above screening criteria values in soils. Only mercury volatilization, therefore, was evaluated further.)

5.1.4 Evaluation Approach

The transport and fate of SoPCs is addressed in this report by evaluating the magnitude and patterns of SoPC concentrations in each medium and the relations among the various media. The evaluation of the patterns shown by the data is also supported by assessment of the expected behavior of each SoPC in the Site environment, based on the literature cited in this report.

Screening for Potential to Impact Surface-Water Quality—As described earlier (in Section 5.1.1), the key issue at this Site with regard to transport and fate of SoPCs in groundwater and seeps is whether the potential exists for net migration to adjacent surface-water bodies at concentrations high enough to be of potential significance with respect to surface-water quality. A screening process was used to determine which Site SoPCs can be ruled out and which merit further evaluation in this report with regard to this potential. This screening process compared dissolved concentrations of SoPCs in groundwater samples from wells around the perimeter of the Site adjacent to surface-water bodies (this includes samples from wells MW-1, 3, 4, 5, 6, and 12) and all filtered seep samples to the surface-water screening criteria. This screening is applied to all Site SoPCs. Only those SoPCs for which the dissolved concentrations in groundwater or seeps exceed the surface-water screening criteria have the potential for migration to the adjacent surface-water bodies at concentrations greater than the surface-water screening criteria.

This screening process identified the following SoPCs and sample locations at which the dissolved concentrations exceeded surface-water screening criteria:

- The mercury surface-water screening criterion of 0.012 $\mu\text{g/L}$ (see Table 1-1) was exceeded in MW-5 (0.57 $\mu\text{g/L}$), SE-04 (0.32 $\mu\text{g/L}$), and SE-06 (1.8 $\mu\text{g/L}$). Note that the IDL for mercury in water was

higher than the surface-water screening criterion ($0.2 \mu\text{g/L}$), so it cannot be determined whether dissolved concentrations in samples in which mercury was not detected exceed the surface-water screening criterion.

- The cadmium surface-water screening criterion of $1 \mu\text{g/L}$ (see Table 1-1) was exceeded at MW-12 ($1.1 \mu\text{g/L}$) and SE-02 ($5.6 \mu\text{g/L}$).
- The copper surface-water screening criterion of $11 \mu\text{g/L}$ (see Table 1-1) was exceeded at SE-02 ($19.8 \mu\text{g/L}$) and SE-06 ($13.1 \mu\text{g/L}$).
- The zinc surface-water screening criterion of $100 \mu\text{g/L}$ (see Table 1-1) was exceeded at MW-2 ($405 \mu\text{g/L}$), MW-3 ($482 \mu\text{g/L}$), SE-01 ($1460 \mu\text{g/L}$), SE-02 ($897 \mu\text{g/L}$), SE-04 ($146 \mu\text{g/L}$), and SE-06 ($366 \mu\text{g/L}$).

This screening process, therefore, determined that the only SoPCs with the potential to migrate from the undeveloped filled area at concentrations high enough to be of potential significance for surface-water quality are mercury, cadmium, copper, and zinc. Mercury and zinc were the only SoPCs identified specifically for surface water in Section 1.4. This means that cadmium and copper are not currently migrating at concentrations that cause surface-water quality criteria to be exceeded. Nevertheless, based on this screening process, the potential for cadmium and copper migration to the adjacent surface water will also be discussed in this report.

5.2 MERCURY

This section contains a discussion of the general behavior of mercury in the environment (Section 5.2.1), followed by a discussion of the Site data (Sections 5.2.2 through 5.2.4).

5.2.1 Behavior of Mercury in the Environment

The transport and fate of mercury in the environment varies with the physical and chemical properties of the various mercurial species. The majority of mercury in the environment occurs as inorganic mercury—either elemental mercury (Hg^0) or mercuric ion (Hg^{2+}). Mercuric ion forms a variety of complexes with anions (e.g., Cl^- , OH^- , and S^{2-}) and adsorbs to mineral colloids (Schuster 1991). Mercuric ion has a particularly strong affinity for sulfide (conditional stability constant of $[\text{Hg}^{2+}][\text{S}^{2-}] = 10^{53.9}$; Dyrssen 1989), including sulfide occurring as sulfhydryl bonds present in organic matter. Organic mercury compounds (e.g., methylmercury, not mercury associated with organic matter) are typically a small fraction (less than one percent) of mercury in the environment, even in soils that are contaminated by industrial production of organic mercury compounds (Hintelmann *et al.* 1995). Under certain environmental conditions, which are not known to be present at this site (such as an anoxic hypolimnion of a lake), methylmercury concentrations can be a much higher percentage of mercury concentrations (Jacobs *et al.* 1995). The following text discusses migration potential and transformation of mercury in soil, water, sediment, aquatic biota, and air.

Migration in Soil and Water Systems—Mercury in soil tends to be relatively immobile because of the tendency of mercury to associate with soil particles, soil organic matter, and sulfides (Schuster 1991). The principle soluble complexes of mercuric ion are $\text{Hg}(\text{OH})_2$, HgCl_2 , and Hg-S-R , where R represents organic ligands containing sulfhydryl groups (Schuster 1991). The relative concentration of each complex depends on pH, oxidation-reduction potential, and ligand concentration. The principle ligand for soluble complexes of methylmercury is dissolved organic matter.

Mercury entering surface water is subject to partitioning between dissolved and particulate phases. Most mercury in water associates with particles such as organic particulate matter and mineral colloids. Gill and Bruland (1990) found that up to 92 percent of total mercury was associated with the particulate fraction in surface-water

samples from California and other areas. Mercury concentrations in filtered water samples, hence, tend to be considerably lower than in unfiltered samples.

Because mercury associates readily with particles, the fate of inorganic mercury in surface water is principally a function of the fate of particles. Over time, particles settle to the bottom of the water column and become part of the sediment. [In quiescent waters, such as the onsite basin, sediment remains in place, and the ultimate fate of mercury associated with particles in these systems is burial.] In moving waters, such as creeks and marshes, surface sediments are often resuspended and transported. *NOT TRUE
GW Migration*

Transformations in Soil and Water Systems—Methylmercury, the organic mercury species of greatest concern because of its potential toxicity and tendency to bioaccumulate, can be formed both biologically and chemically in the environment. This process is called methylation. Methylmercury can also be degraded to elemental mercury. This process is called demethylation. The occurrence of methylmercury at the Site is discussed in terms of both concentration and as a percentage of mercury. In general, methylmercury concentrations are a function primarily of conditions that affect methylmercury formation. Mercury concentrations may also have some influence on methylmercury concentrations. Conditions that favor methylmercury formation are discussed below and include low oxygen concentration, moisture, microbial activity, and the presence of methyl-group (CH_3^-) donors, such as humic matter. Conditions that favor demethylation are also discussed.

Soil—Chemical and biological transformations of mercury in soil include mercury reduction and mercury methylation. Mercuric ion reduction to elemental mercury (a volatile mercury species) results in mercury volatilization to the atmosphere (and consequent loss from soil). Biological methylmercury formation rates in soils are highest under anoxic conditions that favor sulfate-reducing bacteria, the primary methylators of mercury in the environment (Compeau and Bartha 1985). The presence of sulfide (which is produced by sulfate reduction), however, can inhibit methyl mercury production through the formation of stable mercuric sulfide complexes. Little is known about rates

of chemical (i.e., abiotic) methylation of mercury, but it is suspected to occur by the reaction of methyl-group donors, such as humic acid, with mercuric ions in aquatic systems (Weber 1993). Methylmercury concentrations are usually low in surface soil, because methylation rates in dry, oxic soil are generally negligible.

Water—Transformations of mercury in water include reduction, methylation, and demethylation. Mercuric ion reduction to elemental mercury, followed by volatilization, is considered to be a light-induced reaction in surface water that accounts for loss of mercury to the atmosphere. Methylation rates are generally lower in water than in sediment. As in soil, methylmercury concentrations in oxic surface water are generally a small fraction of mercury. Demethylation is an active process in surface water and is thought to result from photodegradation (Sellers *et al.* 1996). Demethylation effectively removes methylmercury from the system by transforming it into elemental mercury, which volatilizes to the atmosphere. Methylmercury, therefore, can be considered fairly short-lived in surface water where oxygen and light are present.

Transport in Aquatic Biota—Another form of mercury transport in surface water and sediment is uptake into aquatic biota. Mercury dissolved in water can enter aquatic biota by direct ingestion or by partitioning to phytoplankton, which form the base of planktonic (i.e., water-based) food webs. Direct ingestion of water is typically a minor route of exposure. Preferential partitioning to phytoplankton results in bioconcentration of methylmercury in phytoplankton, which can then be consumed by zooplankton, which in turn, are consumed by fishes. Mercury associated with sediment can also be ingested by sediment-dwelling organisms such as benthic macroinvertebrates and bottom-feeding fishes. In benthic-based food webs, the concentration of mercury in sediment has a strong effect on the concentration of mercury in the food web. Mercury associated with organisms is transported with the organisms, may be released back into the environment through elimination, and is eventually released back into the environment when the organisms die.

Sediment—In sediment, mercury can continue to undergo transformations, principally methylation and demethylation. In anoxic sediment where sulfide is present, mercury occurs predominately in the form of mercuric sulfide, a very stable and insoluble form that has limited availability for other transformations. However, mercury methylation can proceed, to some extent, even in the presence of sulfide. The highest rates of methylmercury formation occur in anoxic sediment that contains sufficient sulfate to support sulfate-reducing bacteria, but not so much that mercury is sequestered as mercuric sulfide (Compeau and Bartha 1985; Gilmour and Henry 1991). Demethylation is also an active process in sediment and, in some cases, appears to be mediated by the same organisms that methylate mercury (Marvin-DePasquale and Oremland 1998). Abiotic demethylation is suspected to occur in the presence of sulfide, resulting in the formation of mercuric sulfide, which precipitates, and dimethylmercury, which volatilizes to the atmosphere (Craig and Bartlett 1978).

Air—Unlike most metals, mercury can volatilize from soil or water to the atmosphere in the form of elemental mercury (Hg^0). Elemental mercury is formed by the chemical or biological reduction of mercuric ion (Hg^{2+}). Mercury reduction followed by volatilization from soil occurs primarily near the soil surface and is mediated by sunlight (Carpi and Lindberg 1997). Increases in soil temperature result in higher measurements of mercury vapor flux across the soil surface (Gustin *et al.* 1997; Lindberg *et al.* 1995). The concentration of mercury in the air above soil is a function of flux from the soil, background concentrations in air, and weather conditions. Mercury concentrations in air can increase if soil is enclosed (e.g., covered by a shed), or if there is a stagnant mass of air over the site. Mercury vapor is heavier than air and, under quiescent conditions, can settle into low areas. Moderate air movement, however, will cause mercury vapor to mix with the air column. Under most meteorological conditions, air overlying mercury-containing soil mixes readily with air from surrounding locations, resulting in rapid dilution of mercury concentrations. Mercury that volatilizes from the ground into the air, therefore, is expected to dilute rapidly.

5.2.2 Soil, Groundwater, and Seeps

Leaching from Soil to Groundwater—The Phase I data indicate that mercury concentrations in all groundwater samples were below the groundwater screening criterion, except at MW-7, and that no groundwater potentially migrating off the Site contained mercury at concentrations greater than the groundwater screening criterion. Further, mercury concentrations in groundwater samples were above the IDL ($0.2 \mu\text{g/L}$) at only five of the twelve wells sampled.

Four of the five wells with mercury concentrations above the IDL are either in or immediately adjacent to the developed area. These elevated concentrations in groundwater could be related to mercury in soil in the developed area. The mean mercury concentration in surface soil samples was an order of magnitude higher in the developed area than in the undeveloped filled area, and twice as high as in the marsh area. For MW-7, however, Figure 3-3 shows that the direction of groundwater flow from the vicinity of MW-7 is uncertain. Groundwater from the vicinity of MW-7 is flowing either toward the developed area or toward Berry's Creek. The concentration of mercury in groundwater at MW-7, therefore, is not likely to be related to leaching from the soil under the developed area. Also, in either of the two potential directions for groundwater flow, there is another well between MW-7 and the Site perimeter—MW-8 in the direction of the developed area, and MW-6 in the direction of Berry's Creek. Mercury in groundwater at MW-7 may be related to mercury in surface soil in the vicinity of sample locations SS-10 and 18, located southeast of the developed area and generally upgradient of MW-7.

The fifth well with a mercury concentration above the IDL, MW-5, is located within 100 ft south of the suspected location of the former WRCC facility effluent discharge line (initially a ditch and later a pipe—see the BITM, Volume 3) and about 200 ft southwest of the pit that is suspected to be a manhole along the former discharge line. In MW-6, which is about 100 ft north of the suspected former discharge line, mercury was not detected. Mercury in groundwater at MW-5 could be related to leaching of mercury from

soils in the vicinity of surface soil sample station SS- 20. Sample SS-20 had a mercury concentration higher than in the surrounding soil samples.

Methylmercury was detected in all Site wells. The reporting limit for methylmercury in water ($0.00001 \mu\text{g/L}$) was more than four orders of magnitude lower than for mercury in water ($0.2 \mu\text{g/L}$). No groundwater screening criterion is available for methylmercury. With three exceptions, methylmercury concentrations in groundwater at the Site ranged from 0.0013 to $0.00677 \mu\text{g/L}$. Two monitoring wells had methylmercury concentrations lower than this range (MW-10, with $0.00014 \mu\text{g/L}$, and MW-4, with $0.00044 \mu\text{g/L}$), and one well had a methylmercury concentration higher than this range (MW-2, with $0.02 \mu\text{g/L}$). The two wells with lower methylmercury concentrations are at opposite corners of the site: MW-10 is the most upgradient well, and is located near the upgradient property boundary; and MW-4 is the most southerly well. Both mercury and methylmercury concentrations in the surface-soil samples nearest MW-4 are relatively low. MW-2, on the other hand, is located near surface-soil sample location SS-20, which has the highest methylmercury concentration of all soil and sediment samples. The elevated concentration of methylmercury at SS-20 may be a function of localized conditions that support either biological or chemical mercury methylation.

Seeps—Dissolved mercury concentrations in three of the five seep samples were less than the IDL. The two seeps with concentrations above the IDL, SE-04 and SE-06, are located along Berry's Creek north of the tide gate, close to MW-5. The dissolved mercury concentration in SE-06 ($1.8 \mu\text{g/L}$), which is closest to MW-5, was higher than in MW-5 ($0.57 \mu\text{g/L}$), while the concentration in SE-04 ($0.32 \mu\text{g/L}$), which is upstream from SE-06, was lower than in MW-5. Dissolved mercury concentrations in SE-04 and SE-06 were also higher than any of the dissolved total mercury concentrations in surface-water samples from Berry's Creek. These seeps, like MW-5, are in the vicinity of the suspected location of the former WRCC facility discharge to Berry's Creek.

Dissolved methylmercury was detected in all seeps. Dissolved methylmercury concentrations in the seeps along the Diamond Shamrock/Henkel ditch (north) (SE-01,

with 0.0001 $\mu\text{g/L}$, and SE-02, with 0.0003 $\mu\text{g/L}$) were similar in magnitude to dissolved methylmercury concentrations in surface water, and about an order of magnitude lower than methylmercury concentrations in groundwater. For the seeps into Berry's Creek, methylmercury concentrations at SE-03 (0.0015 $\mu\text{g/L}$) and SE-04 (0.0022 $\mu\text{g/L}$) were similar to concentrations in groundwater, while at SE-06, the dissolved methylmercury concentration (0.0003 $\mu\text{g/L}$) was an order of magnitude lower, comparable to the surface-water concentrations.

Potential for Impact on Surface Water—Groundwater migrating to the southwest from the developed area most likely discharges to the Diamond Shamrock/Henkel ditch (north) or the marsh area, except to the extent that the natural groundwater flow may be influenced by groundwater control systems between the developed area and these potential discharge locations. Therefore, the influence, if any, of this potential migration should have been captured by data from MW-12, SW-05, and SE-01. None of these locations have mercury concentrations above the IDL.

One well at which an elevated mercury concentration was measured, MW-5, is along the Site perimeter near Berry's Creek. As discussed in Section 5.1.4, this is the only well along the Site perimeter at which the mercury concentration was known to exceed the surface-water screening criterion (the evaluation was limited because the IDL was higher than the screening criterion). Although groundwater from this location is expected to discharge to Berry's Creek, the amount by which the mercury concentration may attenuate between MW-5 and the Creek is not known. The available data are not conclusive with respect to whether the concentration in MW-5 represents an isolated area of elevated mercury concentration that may rapidly attenuate with distance from the well or a zone of migration that may extend to Berry's Creek.

Methylmercury was detected in all well and seep samples, indicating the potential for net migration of methylmercury in groundwater from the Site. As discussed in Section 5.2.1, however, methylmercury in water in the presence of light and oxygen is likely to undergo demethylation to elemental mercury, which will volatilize from surface water.

Summary—The Phase I data indicate that leaching from soil to groundwater is not causing the groundwater screening criterion to be exceeded except at one location (MW-7). Further, the data indicate that groundwater with total mercury concentrations above the groundwater screening criterion is not migrating offsite.

Dissolved mercury concentrations in the two seeps where the concentrations were above the IDL were greater than surface-water concentrations in Berry's Creek, and one groundwater and two seep samples exceeded the surface-water screening criterion. These relations both indicate the potential for net migration of mercury from the Site to the adjacent surface-water bodies.

Methylmercury concentrations in groundwater are generally an order of magnitude higher than in surface water. Methylmercury concentrations in the seeps varied, with three of the five similar to surface water and two of the five similar to groundwater. These data indicate the potential for net migration of methylmercury from the Site to the adjacent surface water. Once in surface water, however, the methylmercury is expected to undergo demethylation to elemental mercury, which will volatilize.

5.2.3 Surface Water and Sediment

Surface Water—Mercury concentrations were below the IDL ($0.2 \mu\text{g/L}$) in all but two of the filtered surface-water samples, SW-02 ($0.24 \mu\text{g/L}$) and SW-03 ($0.2 \mu\text{g/L}$), both sampled at low tide. In those two samples, the filtered sample concentrations were 15 and 1.5 percent of the unfiltered sample concentrations. Mercury was detected in all unfiltered surface-water samples. Some fraction of the particulate matter in these samples was naturally waterborne, and some may have been introduced during the sampling process through disturbance of the sediment. This indicates that the transport and fate of mercury in surface water is governed principally by the transport and fate of particulate matter.

Dissolved methylmercury concentrations in surface water varied over about an order of magnitude, from 0.00008 to 0.00098 $\mu\text{g/L}$. The highest concentrations were in the onsite basin, where concentrations in both samples were similar and nearly twice as high as the next highest concentrations, which were found in SW-02 and SW-03. Excluding the onsite basin, dissolved methylmercury concentrations in surface water were nearly an order of magnitude lower than in groundwater. The higher values in the onsite basin may be related to conditions that are either more favorable to methylation or less favorable to demethylation. For example, shading of the onsite basin by trees may reduce light penetration and photodegradation of methylmercury.

Methylmercury as a percentage of mercury can be computed for only two filtered surface-water samples (SW-02 and SW-03, both collected at low tide), because mercury concentrations were stated as being below the IDL for all other filtered surface-water samples. For the filtered low-tide samples from SW-02 and SW-03, the dissolved methylmercury concentrations are less than 0.2 percent of dissolved mercury concentrations.

Sediment—Two sediment samples were collected for mercury analysis at each station, one from the 0- to 2-cm depth horizon, and one from the 0- to 15-cm depth horizon. The 0- to 2-cm horizon represents the potentially oxic sediment, and these samples were analyzed for mercury only; the 0- to 15-cm horizon is expected to be principally anoxic, and these samples were analyzed for mercury and methylmercury. Data from the Diamond Shamrock/Henkel Ditch (north), the onsite basin, and Berry's Creek are discussed below.

Diamond Shamrock/Henkel Ditch (north) Sediments—Mercury in these sediments is not likely related to localized continuing sources from the undeveloped filled area along the Diamond Shamrock/Henkel ditch (north). In the Diamond Shamrock/Henkel ditch (north), the mercury concentrations in the 0- to 2-cm and 0- to 15-cm horizons were all in the range of 57 to 98 mg/kg, and five of the six values from these three locations were in

the range of 57 to 70 mg/kg. The methylmercury concentrations were also similar, with values at SD-05 and SD-06 being essentially equal (0.012 mg/kg), and the value at SD-07 (0.02 mg/kg) slightly less than twice as high as those values. As a percentage of mercury, methylmercury concentrations ranged from 0.018 to 0.029 percent. The uniformity of these measured mercury concentrations, both laterally and vertically, indicates that mercury in the ditch sediment may be related to conditions that affect the entire ditch uniformly and remain stable for an extended time period.

Onsite Basin Sediment—In the onsite basin, the mercury concentrations from the two sediment sample locations at both depth horizons fell within a fairly tight range. Three of the four values ranged between 1,180 and 1,280 mg/kg, and the fourth was 856 mg/kg. Mercury concentration in the 0- to 2-cm horizon was nearly identical to that in the 0- to 15-cm horizon at SD-08, and about a third lower than the 0- to 15-cm horizon at SD-09. In the relatively quiescent waters of the onsite basin, the sediment near the surface is expected to be more recently deposited than deeper sediment. The data, therefore, may indicate that more recently deposited sediments at the southeastern end of the basin have lower mercury concentrations than older sediments, or may simply reflect heterogeneity in the sediment. The general uniformity of these measured mercury concentrations, both laterally and vertically, may indicate that mercury in the onsite basin sediment may be related to conditions that affected the entire basin uniformly and remain stable for an extended time period. The data do not, however, necessarily indicate that there is a continuing source. Sedimentation rates may have decreased since the basin was taken out of service as a settling basin for the facility discharge line. The onsite basin may receive some soil erosion from the surrounding area, but the vegetative cover surrounding the basin limits erosion.

Methylmercury concentrations in the onsite basin sediment samples were 0.008 and 0.01 percent of mercury, somewhat lower than in the Diamond Shamrock/Henkel ditch (north) sediment, though methylmercury concentrations were higher than in the ditch. The onsite basin is a likely location for methylmercury formation.

Berry's Creek Sediment—In Berry's Creek, mercury concentrations in sediment were more variable than in either the Diamond Shamrock/Henkel ditch (north) or the onsite basin. Mercury concentrations in the 0- to 2-cm horizon were higher than in the 0- to 15-cm horizon at all three stations downstream of the Site (SD-02, 03, and 04). There was also a mercury sediment concentration gradient decreasing from upstream to downstream in these three 0- to 2-cm samples (11,100 mg/kg at SD-02; 223 mg/kg at SD-03; 0.89 mg/kg at SD-04). In the 0- to 15-cm samples, stations SD-02 (69.6 mg/kg) and SD-03 (70 mg/kg) had nearly identical mercury concentrations, at about twice the concentration in SD-01 (33.8 mg/kg). Mercury was not detected in the 0- to 15-cm sample at SD-04. In the upstream station, SD-01, the 0- to 2-cm (31.3 mg/kg) and 0- to 15-cm (33.8 mg/kg) mercury concentrations were nearly identical.

Methylmercury concentrations at stations SD-01, 02, and 03 varied from only 0.008 to 0.01 mg/kg, a smaller range of variation than found for mercury. Methylmercury concentrations as a percentage of mercury ranged from 0.01 to 0.03, similar to the range of values measured in the Diamond Shamrock/Henkel ditch (north) and the onsite basin. The methylmercury concentration at SD-04 (0.0004 mg/kg) was lower than at the upstream locations, but methylmercury as a percent of mercury was higher, at 0.24 percent. This same relation was found in surface-water mercury concentrations at SW-04.

Marsh Area—Samples from the marsh area were termed soil samples in the Work Plan (CRA 1996), but may also be considered as sediment, because they are usually wet throughout the tidal cycle. The Phase I data indicate that the marsh area, in general, has accumulated higher mercury concentrations than the Creek and ditch sediments, except for the 0- to 2-cm sample at SD-02. All but two of the sediment mercury concentrations are lower than the mean concentration for the marsh-area samples. These data are not, however, directly comparable, because the sediment was sampled from the 0- to 15-cm horizon (0-6 inches), while the marsh soil was sampled from the 0- to 2-ft horizon (with larger roots/tubers removed).

In the marsh, elevated sulfide concentrations, combined with the high organic content of marsh soil and sediment, create the potential for formation of mercuric sulfide, which is extremely insoluble and, hence, resistant to leaching. Mercuric sulfide is also resistant to methylation. Mercury in the marsh, therefore, is expected to remain strongly associated with the soil/sediment.

Summary—Mercury was detected in only two of the filtered surface-water samples, in all but one of the unfiltered surface-water samples, and all but one of the sediment samples. This indicates that mercury in surface water associates with particulate matter and is deposited in sediment. The fate of mercury in surface water and sediment, therefore, is primarily a function of the physical fate of particles.

Mercury in sediments in the Diamond Shamrock/Henkel ditch (north) and the onsite basin is uniformly distributed, possibly indicating a lack of localized continuing sources of mercury to sediments in these areas. Mercury concentrations in Berry's Creek sediment were much more variable.

Mercury methylation rates in the sediment and surface water seem generally low, although there are no known criteria values to which these concentrations can be compared. Rather, the behavior and impact of methylmercury in the ecosystem should be evaluated to assess the significance of the methylmercury concentrations. Such evaluation, if needed, may be part of the ecological risk assessments for the marsh area and Diamond Shamrock/Henkel ditch (north) in this RI/FS, and for Berry's Creek in the subsequent basin-wide RI/FS. In surface water, methylmercury is expected to be short lived, because it is subject to demethylation, forming elemental mercury, which volatilizes from the water. Methylmercury may also be subject to demethylation in sediments, forming mercuric sulfide, which is highly insoluble and chemically stable, and dimethylmercury, which volatilizes.

5.2.4 Air

Concentrations of gaseous mercury were measured in air at the Ventron/Velsicol site at 11 locations over two sampling periods (maximum value of 60.6 ng/m³) and were well below the NJDEP building interior air standard of 300 ng/m³. Volatilization can therefore be considered an insignificant pathway for mercury transport from the site.

Mercury on fugitive dust is also not expected to be an issue at this Site, because the ground cover (pavement in the developed area, thick vegetation in the undeveloped filled area, and thick vegetation and water in the marsh) should prevent significant fugitive dust formation. The Site data confirm this expectation, with a maximum particulate mercury concentration of 1.66 ng/m³.

5.3 OTHER METALS

5.3.1 Soil, Groundwater, and Seeps

This section discusses leaching from soil to groundwater, and potential migration in groundwater, for iron and manganese; potential migration in seeps for cadmium, iron, and manganese; and potential impacts to surface water for cadmium, copper, and zinc. Iron and manganese were identified as SoPCs for groundwater, and cadmium, iron, and manganese were identified as SoPCs for seeps (Section 1.4). Cadmium, copper, and zinc were identified as having the potential to migrate from the undeveloped filled area to surface water at concentrations greater than surface-water screening criteria values in Section 5.1.4.

Leaching from Soil to Groundwater—Iron and manganese both exceeded the groundwater screening criteria in all groundwater samples, except for iron in MW-9. These results are typical in reducing conditions. Both iron and manganese are common components of soil, and under reducing conditions, they form soluble species that can be

leached from the soil (Chappelle 1993). Iron and manganese, therefore, have the potential to migrate in Site groundwater.

Seeps—The groundwater screening criterion for manganese was exceeded in all five filtered seep samples, while the criterion for iron was exceeded in only one filtered sample (SE-04).

Iron concentrations in the filtered seep samples were an order of magnitude or more lower than in the groundwater samples from wells along the Site perimeter with Berry's Creek and the Diamond Shamrock/Henkel ditch (north), except for MW-12. In MW-12, the iron concentration was only twice as high as the highest dissolved concentration in a seep sample. These decreases between the concentrations in groundwater and filtered seep samples may be due in part to the oxygenation and consequent formation of relatively insoluble iron compounds that is expected to occur when the groundwater emerges from the bank. The difference may also be due in part to groundwater mixing with exfiltrating surface water, in which the iron concentrations are also much lower than in groundwater.

Manganese concentrations generally decreased from groundwater samples to filtered seep samples to filtered surface-water samples, but the decreases were not as consistent or pronounced as for iron. Dissolved manganese concentrations in the perimeter wells adjacent to surface-water bodies ranged from 361 to 3840 $\mu\text{g/L}$, while manganese concentrations in seeps ranged from 200 $\mu\text{g/L}$ to 1660 $\mu\text{g/L}$. Manganese concentrations in filtered surface-water samples, excluding the onsite basin, were somewhat lower than in filtered seep samples, ranging from 15 to 948 $\mu\text{g/L}$. The formation of relatively insoluble compounds described above for iron also occur for manganese, but at a slower rate than for iron.

For iron, these relations indicate the potential for migration from the undeveloped filled area to the adjacent surface-water bodies, but with subsequent formation of relatively insoluble compounds in surface water. For manganese, these relations indicate the

potential for net migration of dissolved manganese from the Site to the adjacent surface water.

The groundwater screening criterion for cadmium ($4 \mu\text{g/L}$) was exceeded in only one filtered seep sample, SE-02 ($5.6 \mu\text{g/L}$). Cadmium was not detected in any of the other filtered seep samples. Further, cadmium did not exceed the groundwater screening criterion in any of the groundwater samples, and it was detected in only 2 of the 12 groundwater samples—MW-11 ($2.5 \mu\text{g/L}$), which is not adjacent to a surface-water body, and MW-12 ($1.1 \mu\text{g/L}$). Cadmium was not detected in any filtered surface-water samples (IDL equal to $0.21 \mu\text{g/L}$).

Potential for Impact to Surface Water—Cadmium and zinc concentrations each exceeded the surface-water screening criterion in one well adjacent to a surface-water body (MW-12 for cadmium and MW-3 for zinc), while copper concentrations did not exceed the surface-water screening criterion in any wells. Surface-water criteria were exceeded for cadmium in one filtered seep sample, SE-02 along the Diamond Shamrock/Henkel ditch (north); for copper in two filtered seep samples, SE-02 along the Diamond Shamrock/Henkel ditch (north) and SE-06 along Berry's Creek; and for zinc in four of the five filtered seep samples, SE-01 and SE-02 along the Diamond Shamrock/Henkel ditch (north) and SE-04 and SE-06 along Berry's Creek.

Cadmium—While, there may be a localized source area for cadmium in the vicinity of seep sample SE-02, the data described indicate that there is not a widespread source of cadmium, nor is there a measurable impact to surface water.

Copper—Copper concentrations in filtered seep samples ranged from 3 to $20 \mu\text{g/L}$ along the Diamond Shamrock/Henkel ditch (north) and from 2 to $13 \mu\text{g/L}$ along Berry's Creek. Copper concentrations in filtered surface-water samples were all less than the IDL ($1.5 \mu\text{g/L}$) in the Diamond Shamrock/Henkel ditch (north), ranged from less than the IDL to $6 \mu\text{g/L}$ in Berry's Creek. At SW-04, downstream of the Site, the maximum concentration was $2.7 \mu\text{g/L}$. These data are not conclusive with respect to areas of

potential migration from the undeveloped filled area to the adjacent water bodies. The seep concentrations are slightly higher along the Diamond Shamrock/Henkel ditch (north), but the surface-water concentrations are slightly higher along Berry's Creek.

Zinc—Zinc concentrations in filtered seep samples ranged from 897 to 1460 $\mu\text{g/L}$ along the Diamond Shamrock/Henkel ditch (north) and from 53 to 366 $\mu\text{g/L}$ along Berry's Creek. Zinc concentrations in filtered surface-water samples ranged from 38 to 531 $\mu\text{g/L}$ in the Diamond Shamrock/Henkel ditch (north), from 23 to 49 $\mu\text{g/L}$ in Berry's Creek. At SW-04, downstream of the Site, the concentrations ranged from 32 to 36 $\mu\text{g/L}$. These data show generally higher seep and surface-water concentrations along the Diamond Shamrock/Henkel ditch (north) than in Berry's Creek, indicating the potential for a source of zinc along the Diamond Shamrock/Henkel ditch (north).

Summary—Iron and manganese exceeded groundwater criteria values in essentially all groundwater samples from throughout the Site, and these metals may be migrating from the undeveloped filled area to the adjacent surface-water bodies. Potential iron migration does not appear to be affecting surface-water quality, while any manganese that migrates to the surface-water bodies may stay in dissolved form longer than iron. Comparison of the dissolved copper, zinc, and cadmium concentrations in groundwater and filtered seep samples to both surface-water screening criteria values and to filtered surface-water sample concentrations indicates the potential for net migration of these SoPCs from the Site to the adjacent surface-water bodies. For zinc, the data patterns suggest a source to or along the Diamond Shamrock/Henkel ditch (north).

5.3.2 Surface Water and Sediment

Zinc was the only metal SoPC, other than mercury, identified for surface water. Metal SoPCs, other than mercury, identified for sediment include arsenic, cadmium, chromium, copper, iron, lead, nickel, silver, and zinc. This section discusses the behavior of these SoPCs with respect to their tendency to associate with particulate matter and their

distribution in sediment. The three metal SoPCs identified in Section 5.1.4 as having the potential to migrate from the undeveloped filled area to surface-water bodies at concentrations above the surface-water screening criteria (cadmium, copper, and zinc) are already included in the sediment SoPC list.

Surface Water—Metal SoPCs in surface waters are expected to be associated principally with particulate matter. The data confirm this expectation. The surface-water screening criterion for zinc was exceeded in only one of the 17 filtered samples (SW-05 from the upstream end of the Diamond Shamrock/Henkel ditch [north]). This surface-water sample location corresponds to the sediment sample location with the highest zinc concentration (7,300 mg/kg). These data indicate that surface-water quality with respect to Site SoPCs in the vicinity of the Site is not a significant issue, except for zinc near the upstream end of the Diamond Shamrock/Henkel ditch (north).

Sediment—In contrast to surface water, nine metals were identified as SoPCs for sediment. The presence of these nine metal SoPCs in sediment is not, however, causing surface-water quality screening criteria to be exceeded, except, as noted above, for zinc near the upstream end of the Diamond Shamrock/Henkel ditch (north). This indicates that the SoPCs are strongly bound to the sediments and are not affecting water quality significantly, except in the area noted above.

Of the nine sediment SoPCs, cadmium, chromium, copper, lead, silver, and zinc concentrations in Berry's Creek were an order of magnitude lower in the furthest downstream sediment sample (SD-04) than in the samples from locations adjacent to the Site (SD-01, SD-02, and SD-03). For the other sediment SoPCs—arsenic, iron, and nickel—concentrations at SD-04 were similar in magnitude to concentrations adjacent to the Site.

Concentrations of arsenic, cadmium, chromium, copper, nickel, and silver in sediment increased going downstream in the Diamond Shamrock/Henkel ditch (north). Iron and lead did not show a clear trend. In contrast to most of the other metal SoPCs,

concentrations of zinc in sediment decreased in the downstream direction. The highest concentration in sediment for each of the metal SoPCs, except for mercury and zinc, was found in the sample from SD-07, near the confluence of the Diamond Shamrock/Henkel ditch (north) and Berry's Creek.

The distribution of cadmium, copper, and zinc in sediment are discussed further below, because they were identified in Section 5.1.4 as having the potential to be migrating to surface water at concentrations of potential significance for surface-water quality.

Cadmium—Cadmium concentrations in sediment samples ranged only from 12 to 17 mg/kg in the Diamond Shamrock/Henkel ditch (north), and from 7 to 14 mg/kg in Berry's Creek adjacent to the Site. Cadmium was not detected in the furthest downstream sample in Berry's Creek, SD-04. The highest concentration was at SD-07, which is in the vicinity of the seep with the highest cadmium concentration, SE-02. These data indicate the potential for a localized source from the Site in the vicinity of sample station SD-07 and SE-02. Additionally, this segment of Berry's Creek and the Diamond Shamrock/Henkel ditch (north) may accumulate cadmium from offsite sources in the Berry's Creek basin.

Copper—Copper concentrations in sediment samples from locations adjacent to the Site also varied little, ranging from 190 to 287 mg/kg in the Diamond Shamrock/Henkel ditch (north) and from 110 to 161 mg/kg in Berry's Creek. The concentration at the furthest downstream sample location in Berry's Creek (SD-04) was 11 mg/kg, more than an order of magnitude lower than the concentrations near the Site.

In the Diamond Shamrock/Henkel ditch (north), copper concentrations in sediment increased going downstream. A possible explanation for this pattern is a source at the downstream end of the ditch. The highest copper concentration in a filtered seep sample from along the Diamond Shamrock/Henkel ditch (north) was from SE-02, near the downstream end of the ditch.

The narrow range of variation for copper sediment concentrations in Berry's Creek indicates that either there are no localized sources along Berry's Creek or tidal action rapidly redistributes any localized contributions. Additionally, this segment of Berry's Creek and the Diamond Shamrock/Henkel ditch (north) may accumulate copper from offsite sources in the Berry's Creek basin.

Zinc—Zinc sediment concentrations in the Diamond Shamrock/Henkel ditch (north) were an order of magnitude higher than the concentrations elsewhere and had a pronounced gradient. The concentrations were 7,300 mg/kg at SD-05, (closest to the Diamond Shamrock/Henkel facility), 4,640 mg/kg at SD-06, and 2,640 mg/kg at SD-07 (closest to Berry's Creek). A possible explanation for this pattern is a source of zinc at the upstream end of the Diamond Shamrock/Henkel ditch (north). IT (1988) reports concentrations of zinc in soils at numerous locations on the Diamond Shamrock/Henkel facility that are an order of magnitude greater than those measured on Site. The zinc concentration at SD-04 was an order of magnitude lower than the concentration at the other locations in Berry's Creek. At the upstream sample locations in Berry's Creek, zinc sediment concentrations fell within a tight range, from 602 to 792 mg/kg. These data suggest either that there are no localized sources along Berry's Creek or that tidal action rapidly redistributes any localized contributions. Additionally, this segment of Berry's Creek and the Diamond Shamrock/Henkel ditch (north) may accumulate zinc from offsite sources in the Berry's Creek basin.

Summary—The presence of the nine metals identified as SoPCs in sediment is not causing surface-water screening criteria to be exceeded in the vicinity of the Site, except possibly for zinc in one filtered surface-water sample, indicating that these metals are strongly adsorbed to sediments. Additionally, this segment of Berry's Creek and the Diamond Shamrock/Henkel ditch (north) may accumulate metals from offsite sources in the Berry's Creek basin.

Of the nine metals identified as SoPCs, cadmium, copper, and zinc were evaluated specifically for the potential to affect surface-water quality based on the screening

described in Section 5.1.4. Evaluation of sediment concentration patterns for cadmium, copper, and zinc indicates the potential for localized sources of cadmium or copper near the downstream end of the Diamond Shamrock/Henkel ditch (north) and a source of zinc at the upstream end of the Diamond Shamrock/Henkel ditch (north). The fairly uniform sediment concentrations of cadmium, copper, and zinc in Berry's Creek adjacent to the Site suggest either that there are no localized sources or that tidal action has redistributed the contribution from any localized sources.

5.3.3 Air

Metals in air are not expected to be an issue at this Site, because the ground cover (pavement in the developed area, thick vegetation in the undeveloped filled area, and thick vegetation and water in the marsh) should prevent significant formation of fugitive dust.

5.4 PAHs, OTHER SVOCs, AND PCBs

5.4.1 Soil, Groundwater, and Seeps

No SVOCs were identified as SoPCs in groundwater or seeps. Three polynuclear aromatic hydrocarbons (PAHs) and bis[2-ethylhexyl]phthalate (more commonly known as di(2-ethylhexyl)phthalate, or DEHP) were identified as SoPCs in Site soils, and five PAHs were identified as SoPCs in offsite soils, including the three identified for onsite soils. Soil, groundwater, and seep samples were not analyzed for PCBs.

PAHs— The undeveloped filled portion of the Site is not expected to be a significant source of PAHs to the groundwater or surface water adjacent to the Site. Concentrations of all PAHs identified as SoPCs in the soil were below IDLs in all groundwater, seep, and surface-water samples. These results confirm their expected low mobility in water.

PAHs have a strong tendency to sorb to particles and have generally low solubility (Neff *et al.* 1994). The strength of their tendency to adsorb to particles generally increases, and their aqueous solubility generally decreases, with increasing molecular weight. This sorption is governed largely by the affinity of PAHs for organic matter. In most soils, therefore, and particularly in high-organic-content soils, PAHs tend to have very low mobility in groundwater, unless they occur in the form of a non-aqueous phase liquid (NAPL). There is no evidence for the presence of NAPL at this site.

Low levels of PAHs are ubiquitous in onsite soils, but only benzo[a]pyrene (BaP) exceeds the screening criterion in more than 5 of the 80 Site soil samples (surface and subsurface combined). BaP exceeds the screening criterion in 21 of the 80 onsite soil samples.

Offsite PAH concentrations generally are higher than those on the Site, especially in the samples collected farthest from the Site boundary. Table 4-4 summarizes the concentrations adjacent to and not adjacent to the Site. The mean values not adjacent to the Site range from 1.3 to 2.1 times higher than the mean values adjacent to the Site, and the maximum values not adjacent to the Site are approximately an order of magnitude higher. Further, the mean values for even the samples adjacent to the Site are higher than the mean values for the onsite surface soil samples. The offsite PAHs, therefore, are not likely to be related to the Site.

DEHP—DEHP is a common component of plastics and paints. It is also the breakdown product of a wide range of organic compounds. It is ubiquitous in onsite and offsite soils and is a common laboratory contaminant. Concentrations greater than the screening criterion in soils were found in only two samples, SS-18 and SS-24. The third highest concentration was found at an adjacent station, SS-17. Concentrations in SS-18 and 24 were an order of magnitude higher than in SS-17, and the concentration in SS-17 was nearly an order of magnitude higher than the next highest concentration. SS-17, 18, and 24 are located just south of the Wolf Warehouse and southeast of the Randolph Products property.

DEHP mobility in the groundwater is expected to be similar to that of PAHs. The DEHP screening criterion for groundwater was not exceeded in any wells or seeps. Unlike almost all other SVOCs, however, some DEHP and another phthalate, di-*n*-butyl phthalate, were detected in water samples. All detected concentrations in groundwater and seeps, however, were below the groundwater screening criterion. There is no DEHP screening criterion for surface water.

5.4.2 Surface Water and Sediment

No freshwater chronic surface-water criteria values were identified for SVOCs, and PCBs were not measured in surface water. Several PAHs and two PCB Aroclors[®], however, were identified as SoPCs in sediment. The strong tendency for PAHs to partition to solid-phase materials, described above for groundwater and soil, also applies in surface water and sediment, and it also applies to PCBs. PCBs and high-molecular-weight PAHs have a similar level of affinity for adsorption to organic matter, which in surface-water bodies is most often associated with particles. As with metals, therefore, PAH and PCB transport in surface-water bodies is expected to be related to sediment movement.

PAHs—Based on the discussion in Section 5.4.1, there is no evidence for migration of PAHs from the Site to the adjacent surface-water bodies. Additionally, this segment of Berry's Creek and the Diamond Shamrock/Henkel ditch (north) may accumulate PAHs from offsite sources in the Berry's Creek basin.

PCBs— The pattern of occurrence for PCBs in sediment suggests that the Site is not the source for the PCBs in sediments of the adjacent water bodies. Two PCB Aroclors[®], 1248 and 1260, were detected in sediments. Concentrations of Aroclor[®] 1248 were significantly higher than for Aroclor[®] 1260 in most samples.

Concentrations of Aroclor[®] 1248 in Berry's Creek did not follow an identifiable pattern. They were similar in SD-01 (3,100 $\mu\text{g/kg}$) and SD-03 (4,500 $\mu\text{g/kg}$), but were below the IDL (33 $\mu\text{g/kg}$) in SD-02 and SD-04. In the Diamond Shamrock/Henkel ditch (north), the concentrations show a gradient, increasing in the downstream direction.

Concentrations of Aroclor[®] 1248 at stations SD-05 (1,400 $\mu\text{g/kg}$) and SD-06 (1,800 $\mu\text{g/kg}$) were similar, while the concentration at SD-07 (4,700 $\mu\text{g/kg}$) was significantly higher, approximately equal to the highest concentration in Berry's Creek (at SD-03). Aroclor[®] 1260 was detected at SD-03 (320 $\mu\text{g/kg}$) and SD-07 (430 $\mu\text{g/kg}$).

In the onsite basin, PCB concentrations at SD-08 were 240 $\mu\text{g/kg}$ for Aroclor[®] 1248 and 490 $\mu\text{g/kg}$ for Aroclor[®] 1260, while at SD-09, concentrations were 190 $\mu\text{g/kg}$ for Aroclor[®] 1248 and 260 $\mu\text{g/kg}$ for Aroclor[®] 1260. These values are somewhat greater than the regional background sediment concentrations for total Aroclor[®] of 250 $\mu\text{g/kg}$, reported by Iannuzzi *et al.* (1995) for Newark Bay and its tributaries (including the Hackensack River), but substantially lower than the concentrations in Berry's Creek and the Diamond Shamrock/Henkel ditch (north).

The Site history does not indicate any PCB use at the Site. The onsite basin may have been discharge settling basin for the former WRCC facility, and may also have served the same role for the Randolph Products facility (see Section 2 of the BITM, Volume 3). It also currently receives surface runoff from portions of the undeveloped filled area. The source of the PCBs in the onsite basin is, therefore, uncertain. Approximately half of the total PCB concentration in the onsite basin, however, may be attributable to regional background sources.

The source of the PCBs in the Diamond Shamrock/Henkel ditch (north) is also uncertain. The Diamond Shamrock/Henkel facility, however, is a potential source of PCBs to the sediment. Sediment from the Diamond Shamrock/Henkel facility production pond was reported to have total PCB concentrations ranging from 8,600 to 120,000 $\mu\text{g/kg}$, and facility soils were reported to have total PCB concentrations up to 820,000 $\mu\text{g/kg}$ (IT 1988).

Additionally, this segment of Berry's Creek and the Diamond Shamrock/Henkel ditch (north) may accumulate PCBs from offsite sources in the Berry's Creek basin.

5.4.3 Air

Similar to metals, windblown dust is the primary mechanism for PAH and PCB movement through the air pathway. This is due to the extremely low volatility of these compounds, and their strong association with organic particles in soils. (Fugitive dust in air is not expected to be an issue at this Site, because the ground cover (pavement in the developed area, thick vegetation in the undeveloped filled area, and thick vegetation and water in the marsh) should prevent significant fugitive dust formation.)

5.5 VOCs

5.5.1 Soil, Groundwater, and Seeps

Three VOCs—benzene, toluene, and xylenes—were identified as SoPCs in groundwater, but none was identified for soils. The VOC concentrations in soil and groundwater appear to be very localized, and the concentrations in groundwater apparently attenuate before the Site boundaries are reached. The Site, therefore, is not expected to be a significant source of VOCs to groundwater or to the adjacent surface-water bodies.

Only 5 of the 80 soil samples contained concentrations of these VOCs at levels above the IDLs. Three of these five were in the developed area along Ethel Boulevard, where benzene concentrations in surface soils ranged from 5 to 28 $\mu\text{g}/\text{kg}$. The other two were both from TP-13, where benzene, ethylbenzene, toluene, and xylenes were found. Concentrations in these two samples were 8 and 10 $\mu\text{g}/\text{kg}$ benzene, 190 and 310 $\mu\text{g}/\text{kg}$

ethylbenzene, 70,000 and 23,000 $\mu\text{g/kg}$ toluene, and 110,000 and 22,000 $\mu\text{g/kg}$ total xylenes.

TP-13 is approximately 200 ft south of MW-2, one of the two wells at which benzene was measured above the IDL, and the only well at which toluene, xylenes, and ethylbenzene were measured above the IDL. TP-13, however, is most likely downgradient of MW-2, based on the piezometric head measurements described in Section 3.6.2. The source, therefore, for the VOCs in MW-2 is uncertain. Similarly, the source of the benzene in MW-7 also is uncertain. The concentrations measured in soils along Ethel Boulevard are not high enough to account for the water concentration in MW-7, and the soil samples are most likely not upgradient of MW-7. Regardless of the sources, these VOCs have attenuated to below IDL values at all the wells around the perimeter of the undeveloped filled area, and were also below IDL values in all seep samples. There are no surface-water criteria for these SoPCs.

Further, under oxic conditions, these compounds will degrade readily. Therefore, when these compounds are transported to oxic surface water, they will degrade rapidly or volatilize. Under anoxic conditions, toluene and xylene compounds can degrade biotically to benzoic acid, and subsequently to CO_2 and methane (Chappelle 1993).

5.5.2 Surface Water and Sediment

No VOC screening criteria are available for surface water or sediment. Only a few surface-water samples and no sediment samples contained VOCs at concentrations above IDLs. Only one surface-water sample, SW-02, contained SoPC VOCs (toluene and xylenes) above IDLs. The location of SW-02 is generally downgradient from MW-2, but wells MW-5 and MW-6 and seep samples SE-04 and SE-06, which are also downgradient of MW-2, did not contain VOCs above IDLs, except for 5 $\mu\text{g/L}$ of chlorobenzene in MW-5. These data indicate that the source of the xylenes in SW-02

was not likely the Site. The undeveloped filled area, therefore, is not expected to be a significant source of VOCs to surface water or sediment.

5.5.3 Air

VOC compounds will volatilize into air. However, given the low concentrations of VOCs in soils, this process is not likely to be significant at the Ventron/Velsicol Site.

6.0 HUMAN HEALTH RISK ASSESSMENT

To be provided.

7.0 ECOLOGICAL RISK ASSESSMENT

To be provided.

8.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The objectives of this remedial investigation were to identify substances of potential concern (SoPCs) and characterize their sources, spatial distribution, transport, and fate. The remedial investigation was conducted in accordance with the approved Work Plan, and the objectives were met.

8.1 SUMMARY

8.1.1 Nature and Extent of Contamination

- The SoPCs identified for the Site included 12 metals, 3 VOCs, 13 SVOCs, and 2 PCB Aroclors[®]
- In groundwater samples, screening criteria values were exceeded for only three SoPCs in only two wells (arsenic and nickel in MW-6 and mercury in MW-7), except for iron and manganese, for which exceedances were ubiquitous.
- In seep samples, one SoPC in only one seep (cadmium in SE-02) exceeded the screening criteria value, except for iron and manganese, which were exceeded in one and five samples, respectively.
- In surface-water samples, surface-water screening criteria for SoPCs were exceeded in only one sample for zinc (SW-05), two samples for mercury (SW-02 and SW-03 at low tide), and one sample for lead (SW-09 in the onsite basin). Further, the value for lead is not reliable

because the unfiltered sample had a lower reported concentration than the filtered sample.

- Screening criteria exceedances were more numerous in soil and sediment samples than in water samples. The degree by which the screening criteria values were exceeded was also greater for soil and sediment samples.

8.1.2 Transport and Fate of SoPCs

- Groundwater mounding in the undeveloped filled area creates a radial flow pattern in that area (flow directed outward from approximately the center of the area), redirecting the flow that would normally result from the regional flow patterns.
- The SoPCs at this Site are associated with the soils, sediments, and suspended solids to a much greater extent than with groundwater or surface water.
- Mercury was not detected in samples from monitoring wells, seeps, or surface water in locations downgradient of the developed area.

8.2 CONCLUSIONS

The principal transport-and-fate issue addressed in this remedial investigation was the potential for SoPCs from the developed area and the undeveloped filled area to migrate from those areas to the adjacent surface-water bodies, including the marsh area, which is part of the contiguous tidal wetlands of Berry's Creek.

8.2.1 Groundwater Movement

The hydrology/hydrogeology of the Ventron/Velsicol Site is complex. Whereas the entire Site was once a marsh area and, consequently, a regional discharge area for groundwater, it now has three distinctly different hydrologic regimes. The pervious fill in the undeveloped filled area has created a local groundwater recharge area and associated groundwater mound, which creates a radial flow pattern from the center toward the perimeter of the undeveloped filled area, interrupting the regional flow toward Berry's Creek. The impervious surface cover in the developed area creates a zone with essentially no groundwater recharge and a steep gradient across this area. The Marsh area is still a local and regional groundwater discharge area. It is also part of the contiguous tidal wetlands of Berry's Creek. The presence of tidal fluctuations in Berry's Creek and connected water bodies, such as the marsh area and the Diamond Shamrock/Henkel ditch (north), adds further complexity to the Site hydrology/hydrogeology.

8.2.2 SoPC Migration

The dominant pathways by which SoPC Migration may occur are migration in groundwater or soil erosion along the creek bank and the transition zone to the marsh area. Based on the observed SoPC concentrations in groundwater and seeps around the Site perimeter, and the expected attenuation of SoPCs in groundwater by Site soil, migration rates in groundwater of SoPCs into the marsh from the uplands are expected to be small.

8.3 RECOMMENDATIONS

8.3.1 Future Site Activities

Several factors suggest that the next steps for this Site should focus on developing a remedy for the undeveloped filled area. The undeveloped filled area is similar in many respects to an area of historical fill or a landfill site, situations that are candidates for a presumptive containment remedy under NJDEP and U.S. EPA guidance (U.S. EPA 1990, 1991, 1993a, 1995a; NJDEP 1998). (A containment remedy that includes a semi-permeable cap would substantially reduce the infiltration rate, eliminating the groundwater mound and, hence, much of the driving force for potential SoPC migration from the undeveloped filled area to the adjacent surface-water bodies.) A containment remedy could also deal with the potential for a preferential pathway along the former effluent discharge line, precluding the potential for direct contact with surface soils and debris.

Tidal Influences

The next step for the Ventron/Velsicol Site, therefore, should be to perform a focused feasibility study for a containment remedy for the undeveloped filled area. A streamlined risk assessment (qualitative identification of potential risks only) in accordance with the presumptive remedy guidance (U.S. EPA 1993a) would then be developed for the current Site conditions, and a quantitative risk assessment would be developed for the post-remediation conditions.

After the remedy is implemented, the Site should then be monitored until conditions in the undeveloped filled area have stabilized. The monitoring plan would include periodic measurements of the piezometric surface and chemical analysis of groundwater samples. Once conditions have stabilized, the next steps would be to develop a recommendation for a Phase II remedial investigation for the marsh area, and then to conduct that investigation.

8.3.2 Phase IA Remedial Investigation

Concurrent with the focused feasibility study for the undeveloped filled area, the following additional data should be collected:

*Is this necessary
we know the
source*

- Further delineate offsite surface-soil mercury concentrations to define the limits of surface-soil concentrations above the NRDCSCC criterion (270 mg/kg) along the northwestern Site boundary (near Park Place East). Four samples are proposed on extensions of the Site grid to the northwest. The sample collection would target locations generally between the railroad tracks and the next set of buildings to the northwest. Delineation to the NRDCSCC criterion, rather than the RDCSCC criterion, is recommended because of the extensive infrastructure and commercial/industrial development in this area. The nearest residential area is approximately ¼ mile away, on the northwest side of Route 17. These samples would be analyzed only for mercury.
- A second round of groundwater samples for chemical analysis from the existing Site wells. These results would be used together with the Phase I data to establish a baseline against which to evaluate post-remedy conditions. The samples would be analyzed for the SoPC metals, VOCs, methylmercury, and the conventional parameters described below.
- Quarterly groundwater elevation measurements from the existing Site wells over the course of one year to evaluate potential seasonal changes in groundwater flow direction at the Site and establish a baseline against which to evaluate post-remedy conditions.

- Conventional parameters for groundwater analysis would include ferrous iron, dissolved organic carbon, nitrate, sulfide, and ammonia, in addition to the conventional parameters analyzed in Phase I.
- In Phase IA, standard analytical methods should be selected to produce detection limits lower than both groundwater and surface-water screening criteria values for the analytes of interest.

Following approval of the generalized plans outlined above, the full scope of the Phase IA sampling program, including the specific number of samples, locations of sampling points, and chemical analysis methods, would be presented in a Phase IA sampling and analysis plan.

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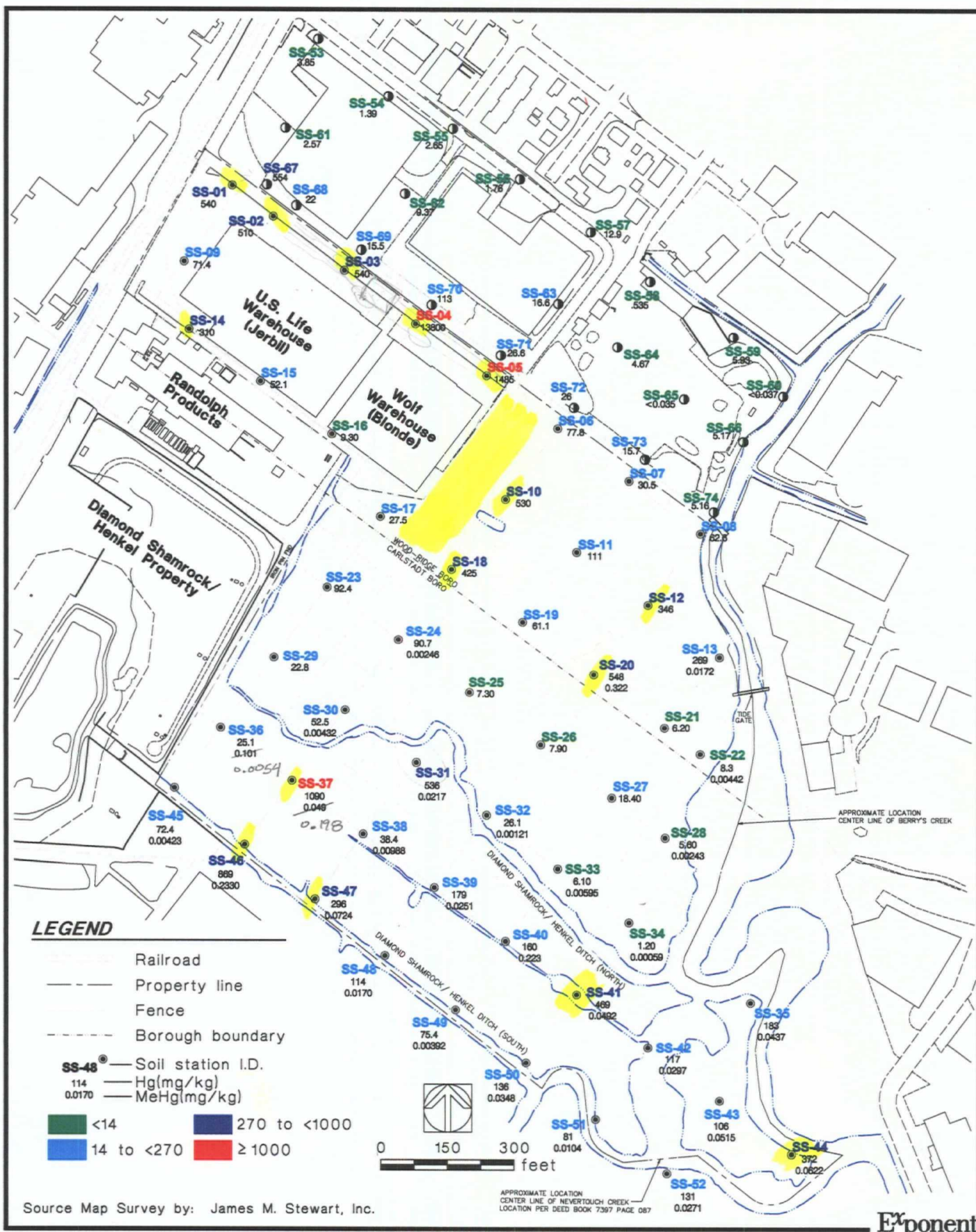


Figure 4-1. Mercury concentrations in surface soil samples Fall 1997, May 1998.

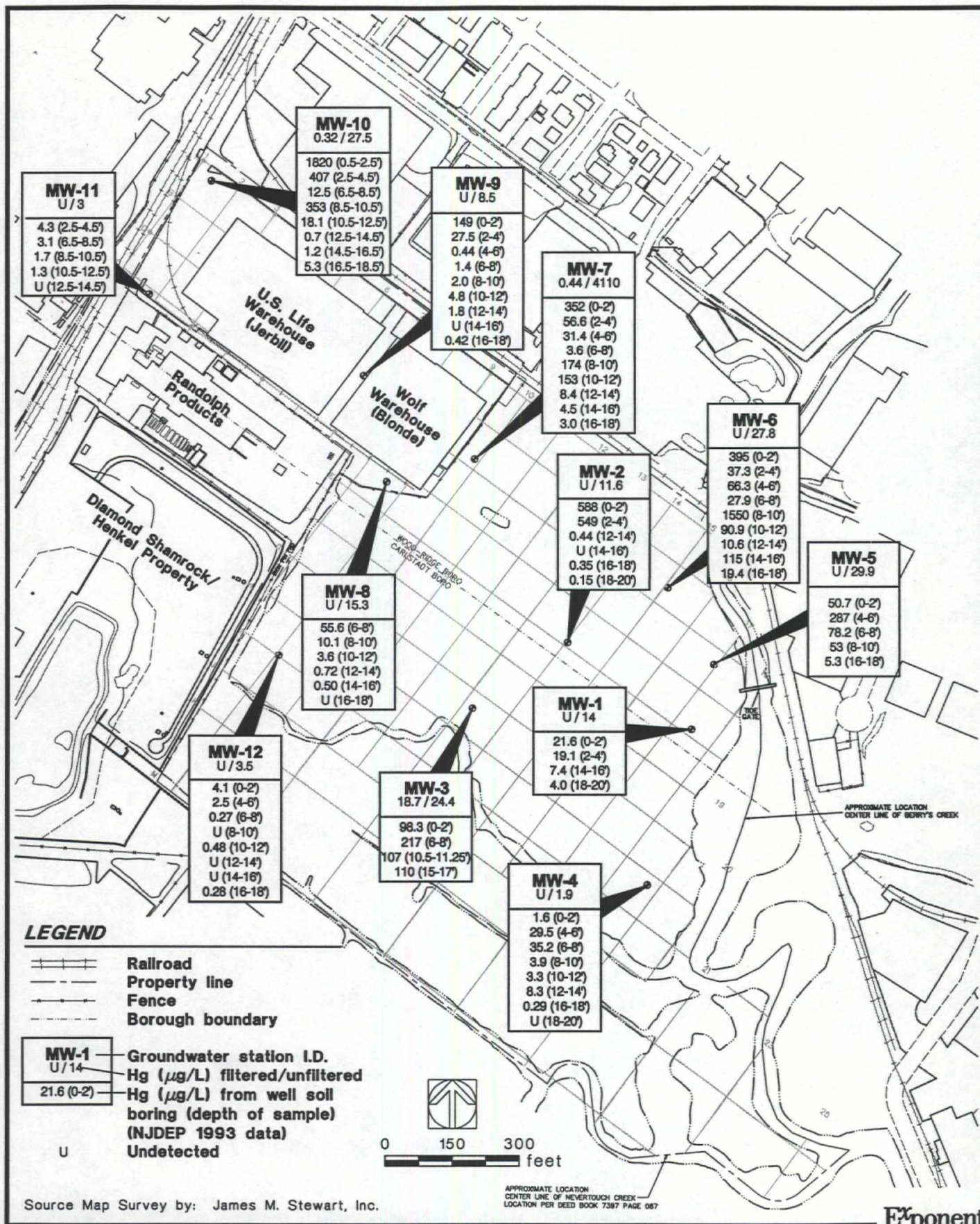


Figure 4-2. Mercury concentrations in groundwater and soil borings as reported by NJDEP (1993) at the Ventron/Velsicol Site.

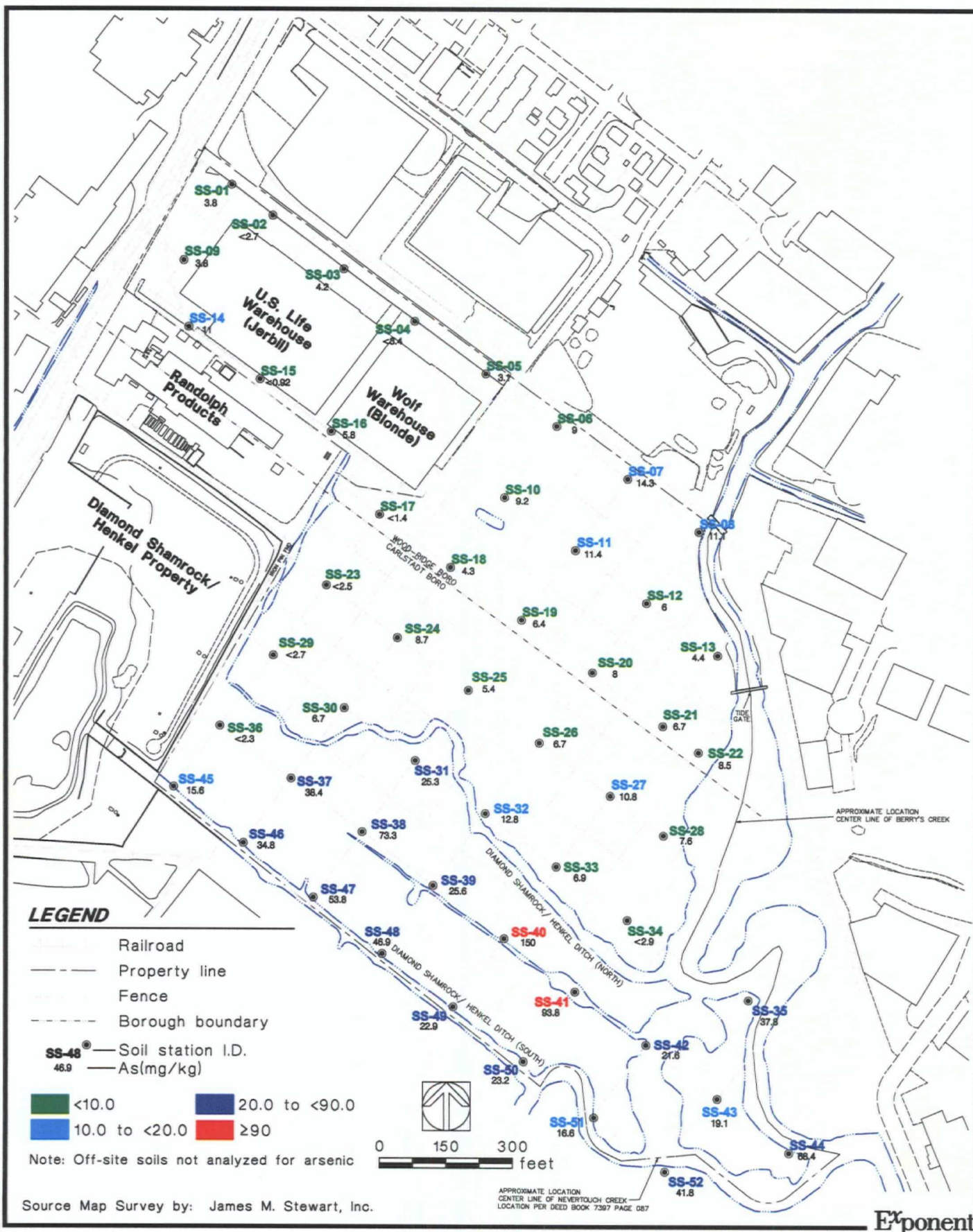


Figure 4-3. Arsenic concentrations in surface soil samples Fall 1997.

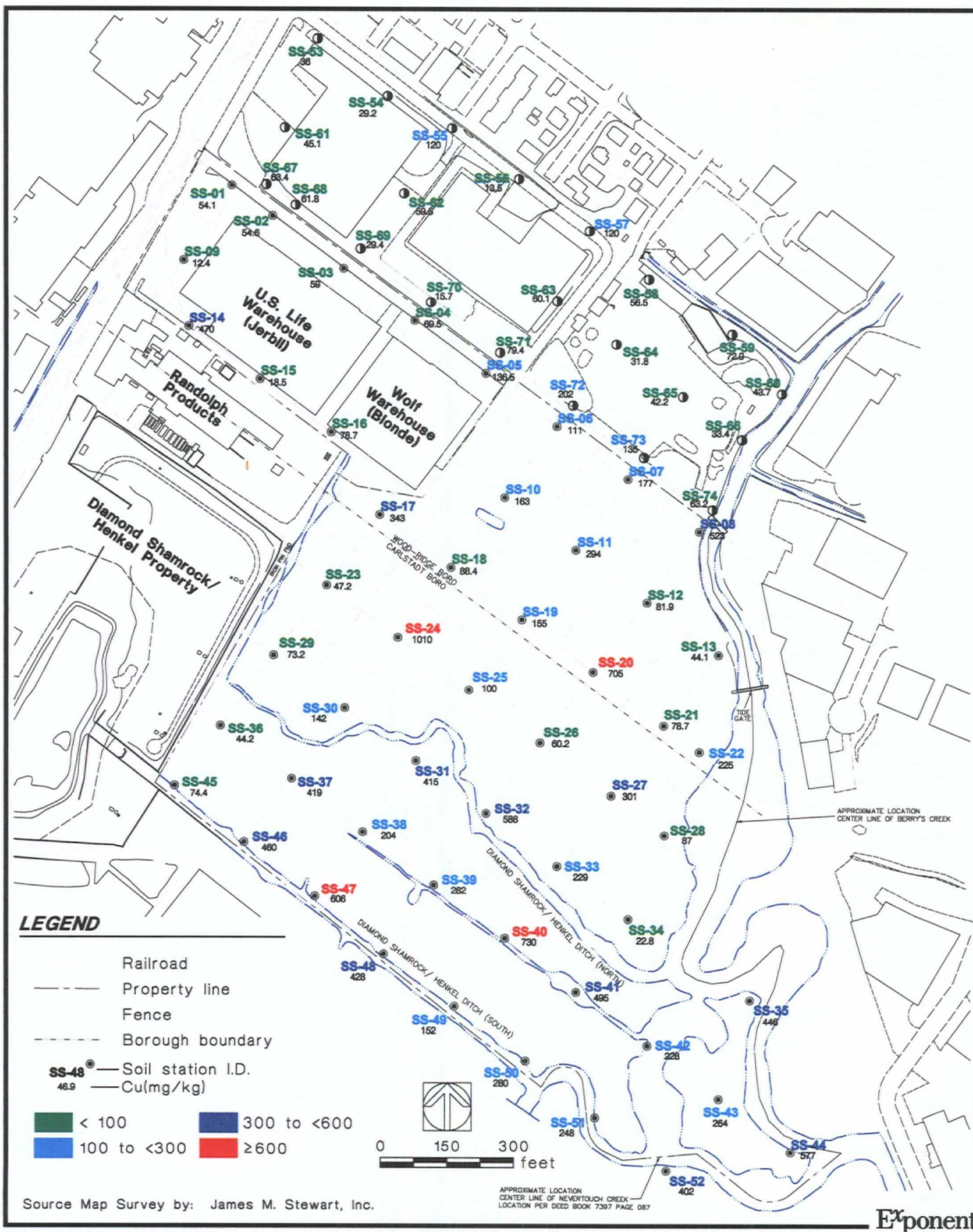
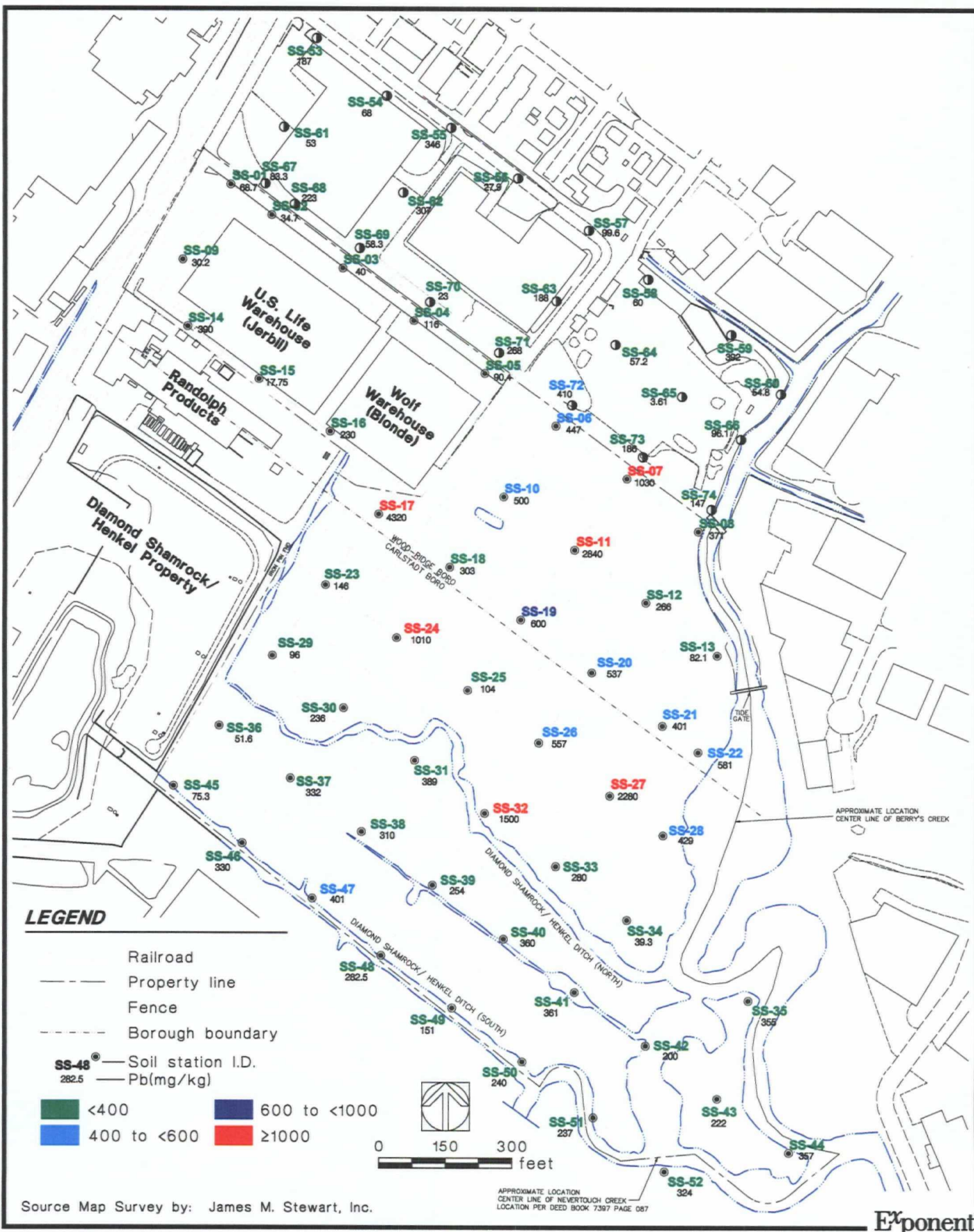
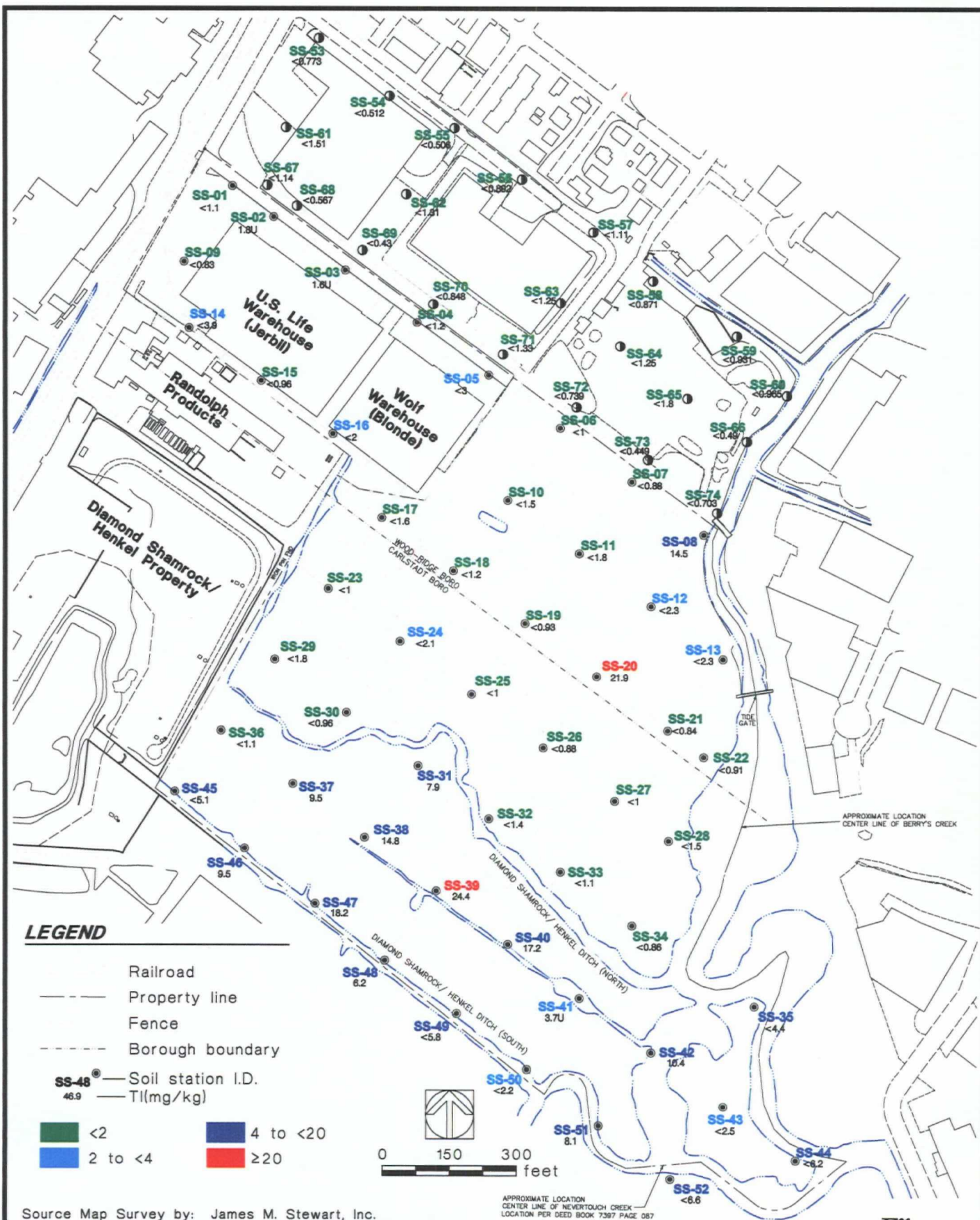


Figure 4-4. Copper concentrations in surface soil samples Fall 1997, May 1998.



Exponent

Figure 4-5. Lead concentrations in surface soil samples Fall 1997, May 1998.



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Figure 4-6. Thallium concentrations in surface soil samples Fall 1997, May 1998.

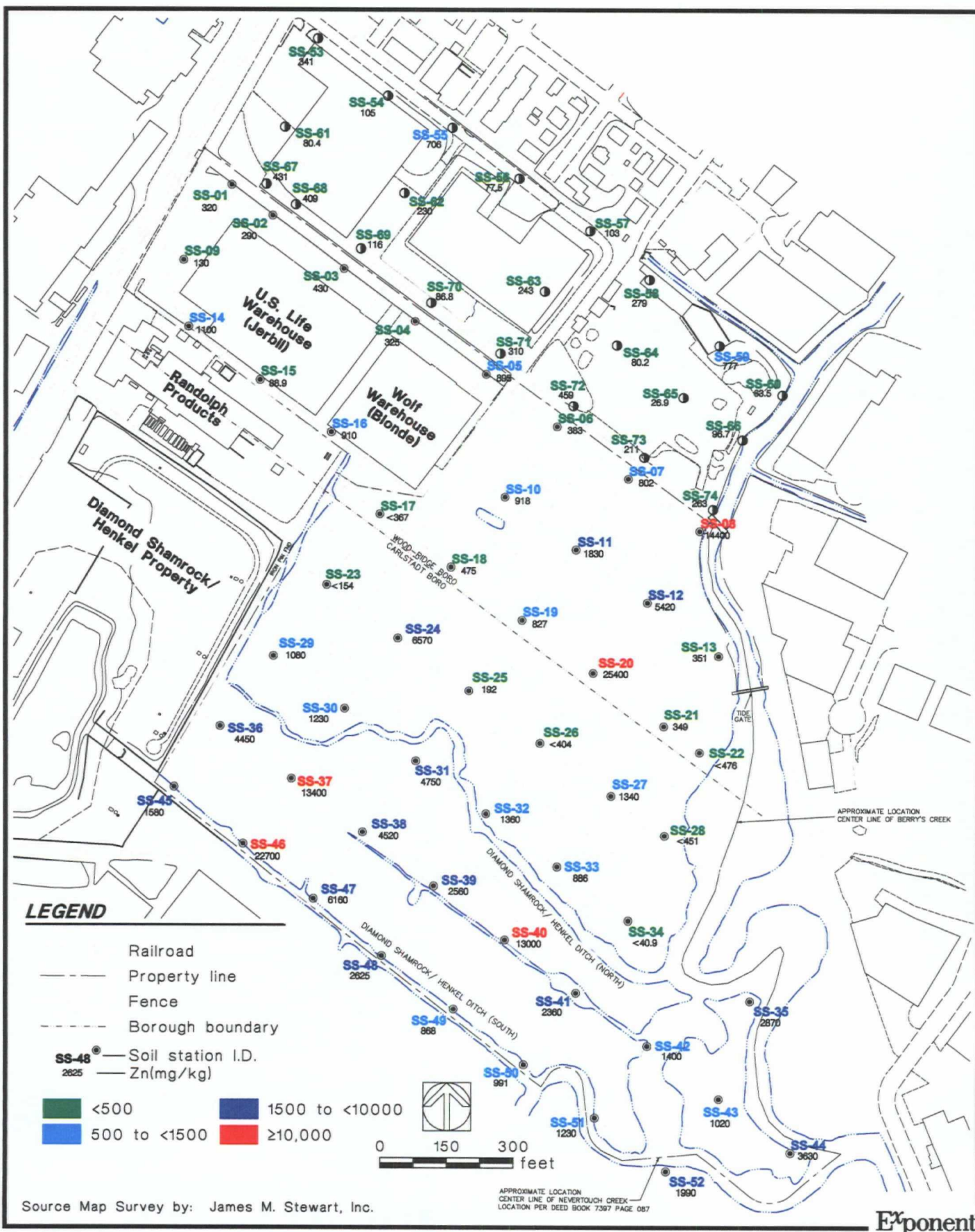


Figure 4-7. Zinc concentrations in surface soil samples Fall 1997, May 1998.

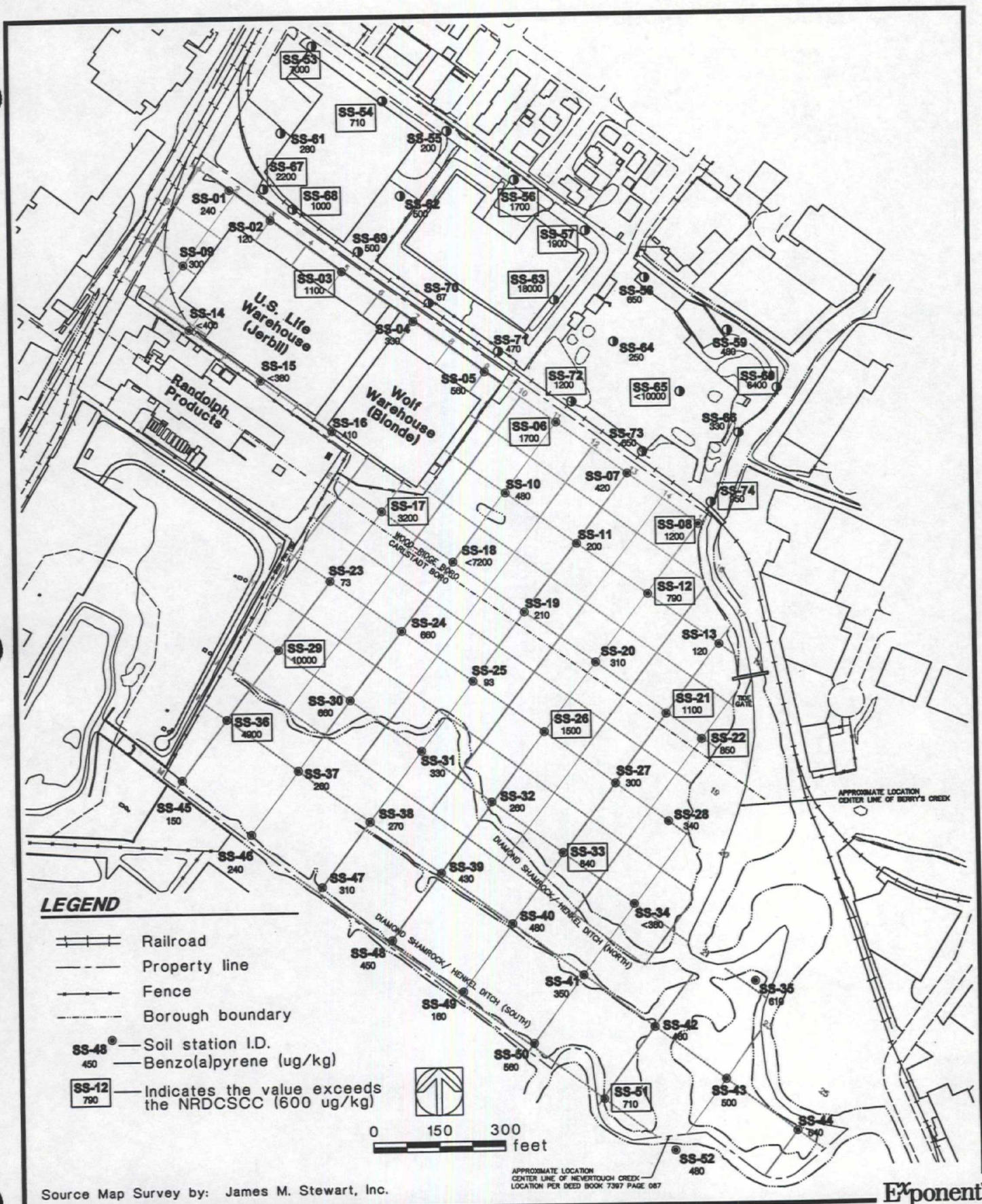


Figure 4-8. Benzo(a)pyrene concentrations in surface soil samples
Fall 1997, May 1998.

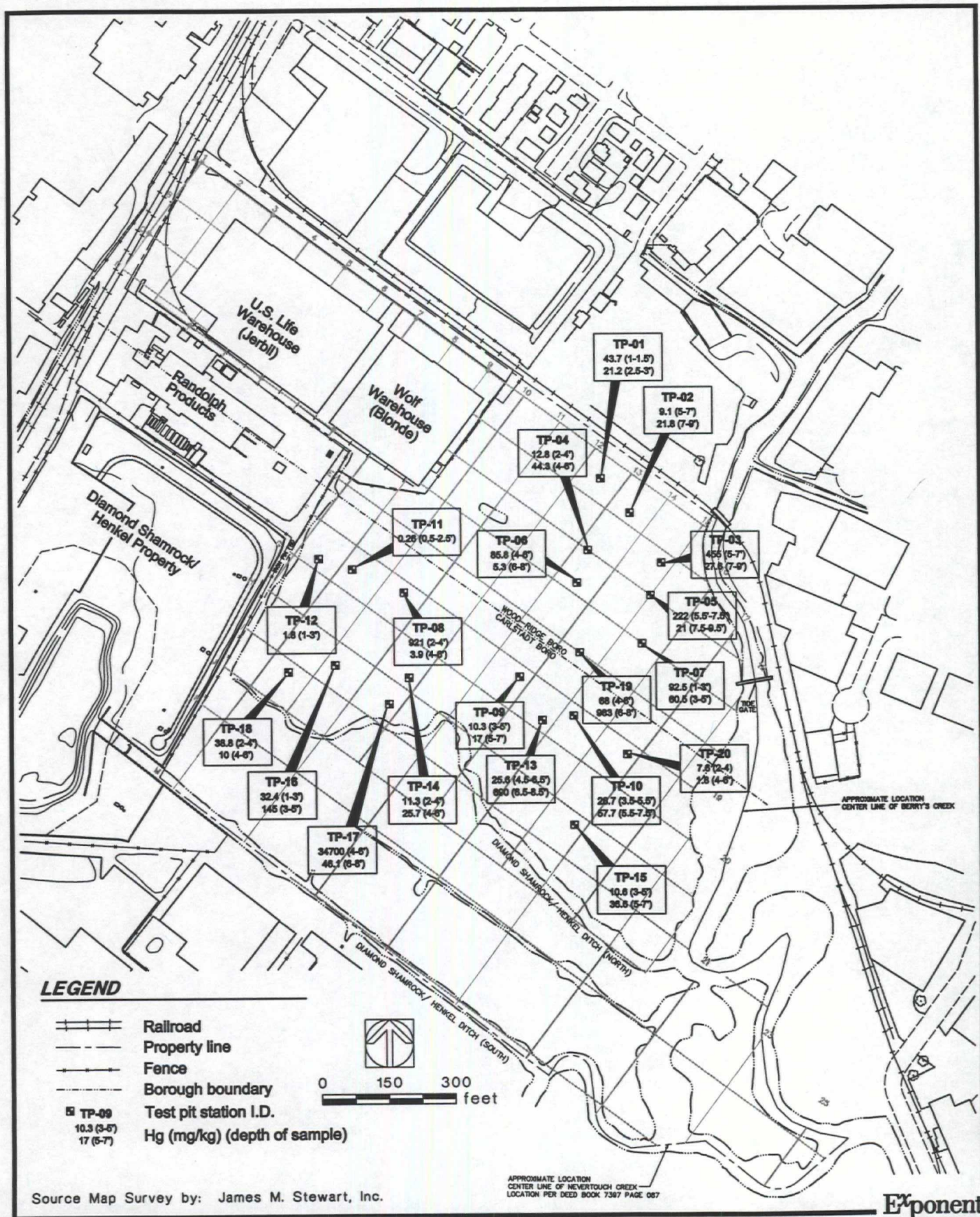


Figure 4-9. Mercury concentrations in subsurface soil samples March 1998.

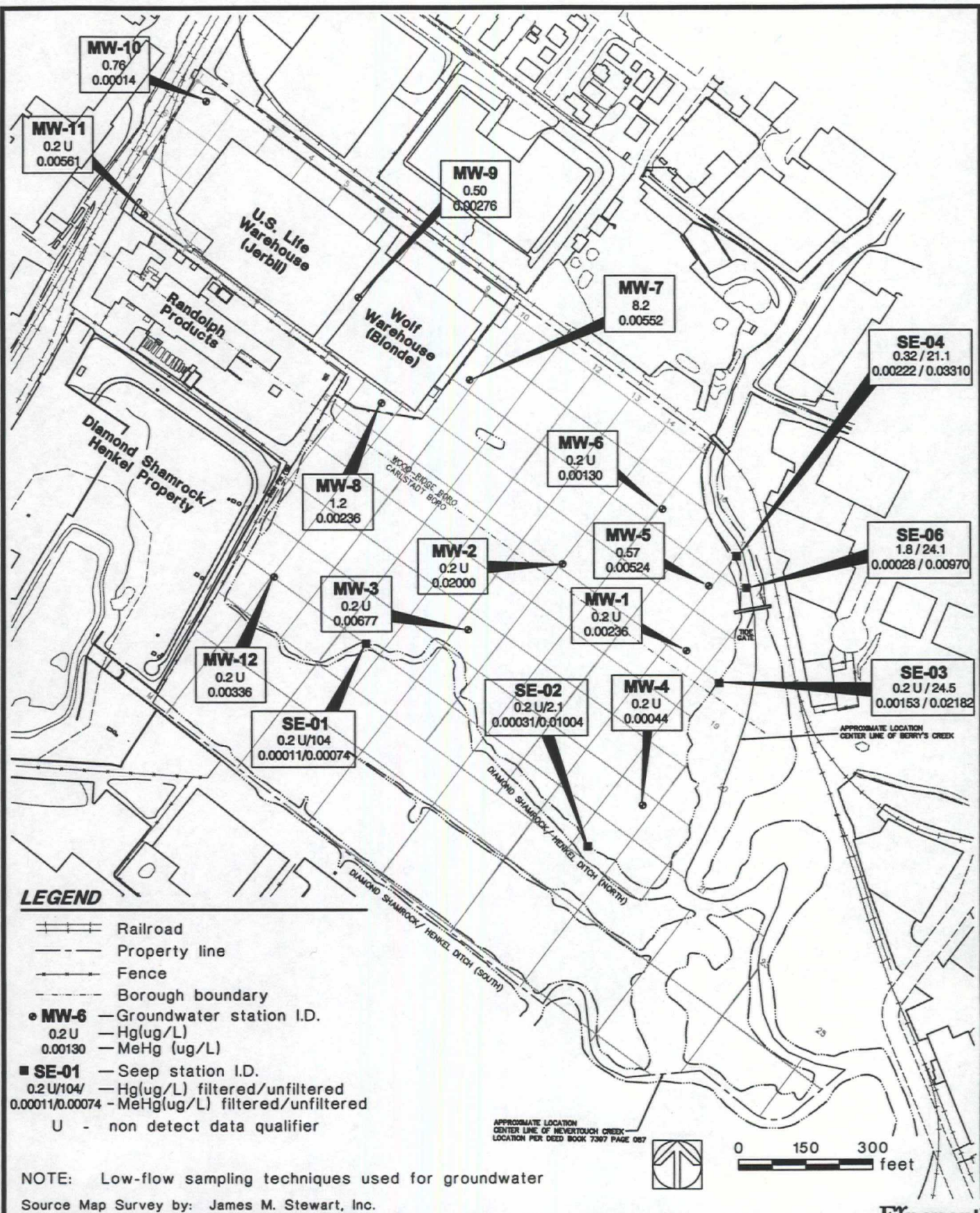


Figure 4-10 Mercury concentrations in groundwater and seep samples Fall 1997.

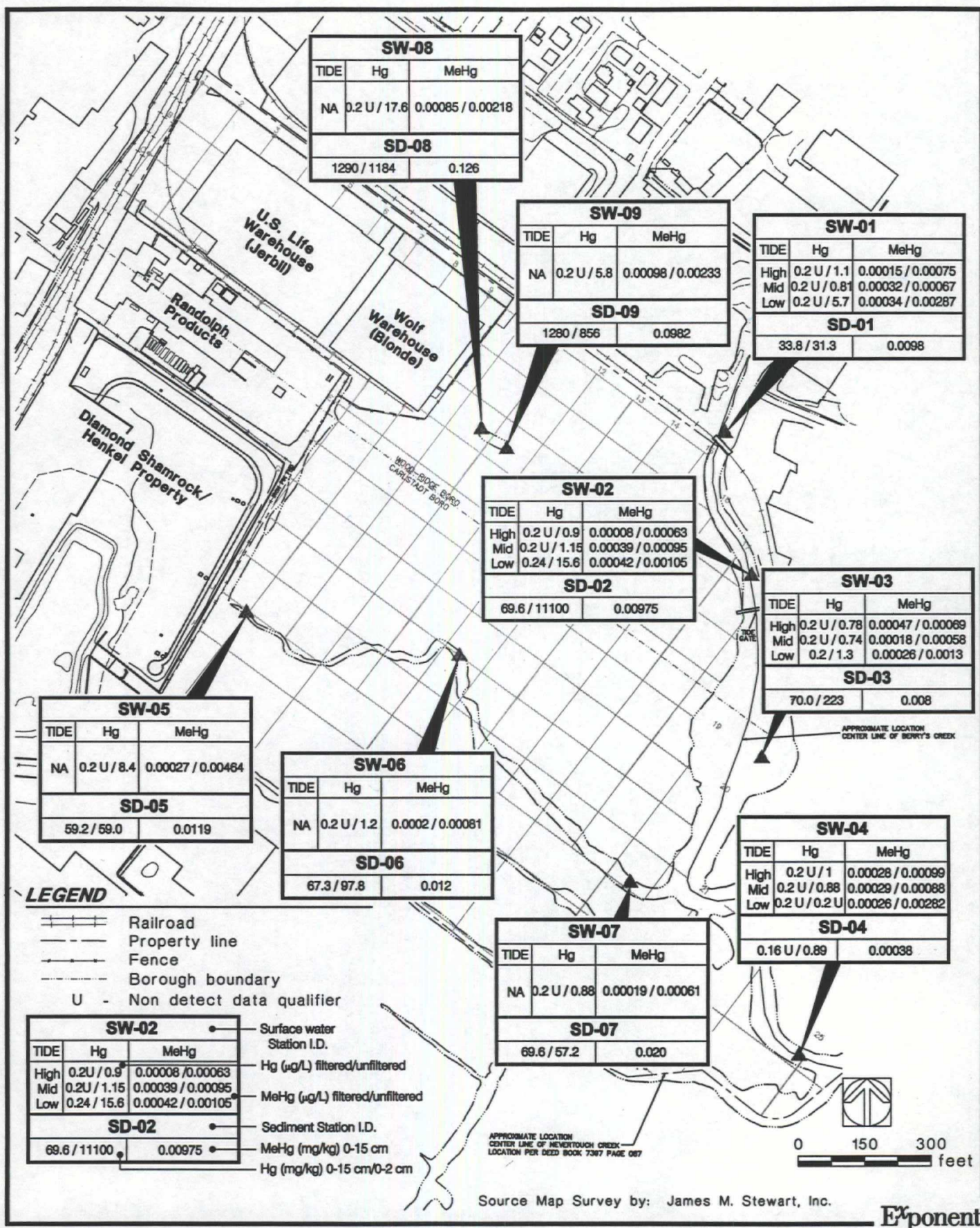


Figure 4-11. Mercury concentrations in surface water and sediment samples Fall 1997.

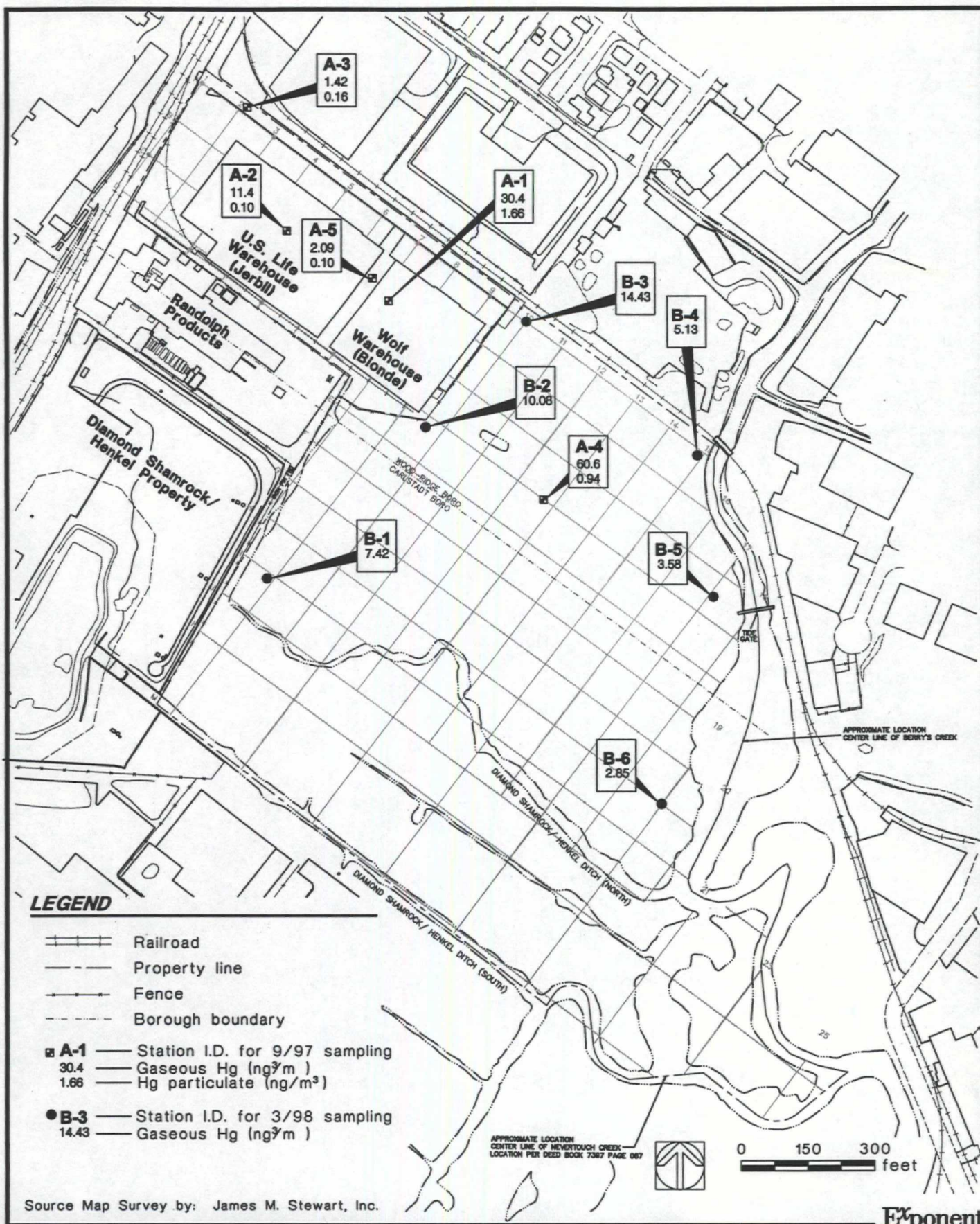
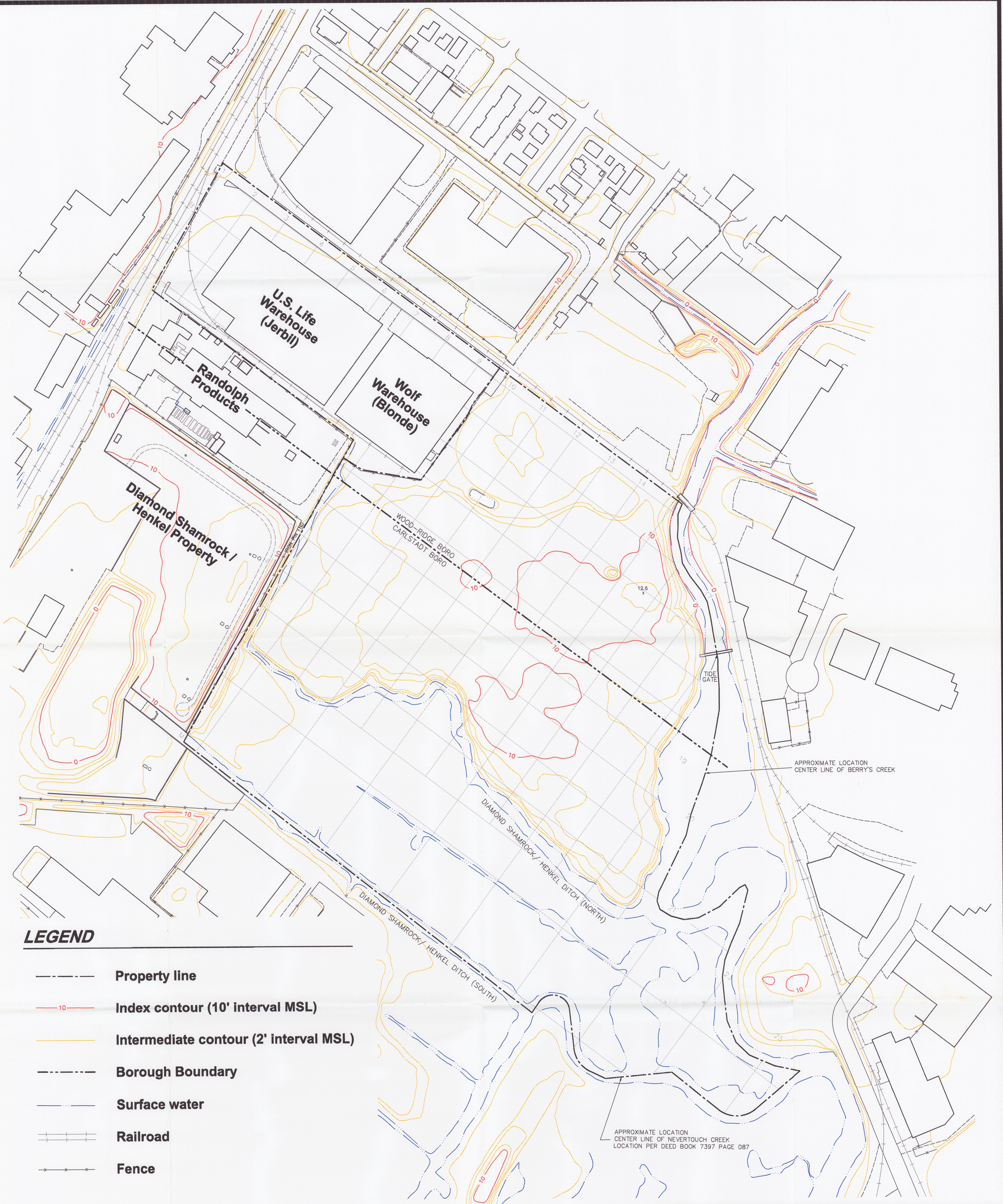
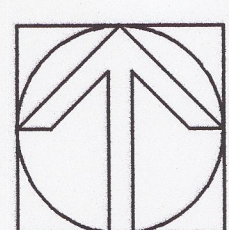


Figure 4-12. Mercury concentrations in air samples Fall 1997, March 1998.



LEGEND

- Property line
- Index contour (10' interval MSL)
- Intermediate contour (2' interval MSL)
- Borough Boundary
- Surface water
- Railroad
- Fence



0 200 400 feet

Plate 1. Topography of the Ventron/Velsicol Site.

Source Map Survey by: James M. Stewart, Inc.
Prepared by: Exponent

TABLE 1-1. NEW JERSEY SCREENING CRITERIA

	Soils (NRDCSCC) ^a	Sediment (Freshwater)	Groundwater/ Seeps	Surface Water
Mercury				
Mercury	270 mg/kg	0.2 mg/kg	2 µg/L	0.012 µg/L
Metals				
Arsenic	20 mg/kg	6 mg/kg	8 µg/L	190 µg/L ^b
Beryllium	1 mg/kg	—	20 µg/L	—
Cadmium	100 mg/kg	0.6 mg/kg	4 µg/L	1 µg/L ^b
Chromium	—	26 mg/kg	100 µg/L	10 µg/L ^{b, c}
Copper	600 mg/kg	16 mg/kg	1,000 µg/L	11 µg/L ^b
Iron	—	—	300 µg/L	—
Lead	600 mg/kg	31 mg/kg	10 µg/L	2.5 µg/L ^b
Manganese	—	—	50 µg/L	—
Nickel	2,400 mg/kg	16 mg/kg	100 µg/L	160 µg/L ^b
Silver	4,100 mg/kg	1 mg/kg	—	—
Sodium	—	—	50,000 µg/L	—
Thallium	2 mg/kg	—	10 µg/L	—
Zinc	1,500 mg/kg	120 mg/kg	5,000 µg/L	100 µg/L ^b
Volatile Organic Compounds				
Benzene	13,000 µg/kg	—	1 µg/L	—
Chlorobenzene	680,000 µg/kg	—	4 µg/L	—
Toluene	1,000,000 µg/kg	—	1,000 µg/L	—
Xylene isomers (total)	1,000,000 µg/kg	—	40 µg/L	—
Semi-Volatile Organic Compounds				
Anthracene	10,000,000 µg/kg	220 µg/kg	2,000 µg/L	—
Benz[a]anthracene	4,000 µg/kg	320 µg/kg	—	—
Benzo[a]pyrene	660 µg/kg	370 µg/kg	—	—
Benzo[b]fluoranthene	4,000 µg/kg	—	—	—
Benzo[g,h,i]perylene	—	170 µg/kg	—	—
Benzo[k]fluoranthene	4,000 µg/kg	240 µg/kg	—	—
Bis[2-ethylhexyl]phthalate	210,000 µg/kg	—	30 µg/L	—
Chrysene	40,000 µg/kg	340 µg/kg	—	—
Dibenz[a,h]anthracene	660 µg/kg	60 µg/kg	—	—
Fluoranthene	10,000,000 µg/kg	750 µg/kg	300 µg/L	—
Fluorene	10,000,000 µg/kg	190 µg/kg	300 µg/L	—
Indeno[1,2,3-cd]pyrene	4,000 µg/kg	200 µg/kg	—	—
Phenanthrene	—	560 µg/kg	—	—
Pyrene	10,000,000 µg/kg	490 µg/kg	200 µg/L	—
PCBs				
Aroclor(R) 1248	2,000 µg/kg ^d	30 µg/kg	0.5 µg/L ^d	0.14 µg/L ^d
Aroclor(R) 1260	—	5 µg/kg	—	—

Notes: See text in Section 1.4 for complete criteria references.

^a NRDCSCC: Non-residential Direct Contact Soil Cleanup Criteria

^b Criterion value represents a dissolved concentration

^c Value is for Cr(VI); criterion for Cr(III) is 180 µg/L

^d Value is for total PCBs

— No criterion value for compound

TABLE 1-2. NUMBER OF NEW JERSEY SCREENING CRITERIA EXCEEDANCES

	Surface Soils (n=52)	Subsurface Soils (n=38)	Groundwater (n=12)	Leachate/ Seeps (n=5)	Surface Water (n=17)	Sediment (n=9)
Mercury						
Mercury	16	5	1	0	2	8
Metals						
Arsenic	15	6	1	0	0	8
Beryllium	0	2	0	0	--	--
Cadmium	0	0	0	1	0	8
Chromium	--	--	0	0	0	8
Copper	4	3	0	0	0	8
Iron	--	--	11	1	--	--
Lead	6	24	0	0	1	8
Manganese	--	--	12	5	--	--
Nickel	0	0	1	0	0	7
Silver	0	0	--	--	--	8
Sodium	--	--	8	5	--	--
Thallium	12	3	0	0	--	--
Zinc	19	14	0	0	1	8
Volatile Organic Compounds						
Benzene	0	0	2	0	--	--
Chlorobenzene	0	0	2	0	--	--
Toluene	0	0	1	0	--	--
Xylene isomers (total)	0	0	1	0	--	--
Semi-Volatile Organic Compounds						
Anthracene	0	0	0	--	--	5
Benz[a]anthracene	1	1	--	--	--	7
Benzo[a]pyrene	12	9	--	--	--	7
Benzo[b]fluoranthene	3	2	--	--	--	--
Benzo[g,h,i]perylene	--	--	--	--	--	7
Benzo[k]fluoranthene	1	1	--	--	--	5
Bis[2-ethylhexyl]phthalate	2	0	0	0	--	--
Chrysene	0	0	--	--	--	7
Dibenz[a,h]anthracene	1	1	--	--	--	5
Fluoranthene	0	0	0	0	--	7
Fluorene	0	0	0	--	--	1
Indeno[1,2,3-cd]pyrene	0	1	--	--	--	7
Phenanthrene	--	--	--	--	--	5
Pyrene	0	0	0	0	--	8
PCBs						
Aroclor(R) 1248	NA	NA	NA	NA	NA	7
Aroclor(R) 1260	NA	NA	NA	NA	NA	4

Notes: Substances of potential concern are highlighted

See Table 1-1 for criteria values

Exceedances for soil are based on comparison with the NRDCSCC

Exceedances for seeps and surface water are based on dissolved concentrations

Exceedances for sediment are based on the 0 - 15 cm sample interval

n = number of sample locations

-- No media-specific criterion for compound

NA - compound not analyzed in medium

TABLE 2-1. SUMMARY OF CHEMICAL ANALYSES

Component of Field Investigation	Analytes	Method Reference ^a	Number of Sample Locations (breakdown by area of Site)	QA/QC Samples
Onsite Surface Soil	TCL VOCs TCL SVOCs TAL metals	EPA CLP SOW OLM03.1 EPA CLP SOW OLM03.1 EPA CLP SOW ILM04.0	52 (9 developed area, 24 filled area, 19 marsh area)	3 duplicates 9 rinsate blanks 1 trip blank
	Methyl mercury	Bloom (1989) and Liang (1994)	28 (9 filled area, 19 marsh area)	2 duplicates 2 rinsate blanks
Offsite Surface Soil	Select TCL SVOCs: benz(a)anthracene, dibenz(a,h)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, bis(2-ethylhexyl)phthalate Select TAL metals: Antimony, cadmium, copper, lead, total mercury, thallium, zinc	EPA CLP SOW OLM03.1 EPA CLP SOW ILM04.0	22	2 duplicates 2 rinsate blanks
Subsurface Soil	TCL VOCs TCL SVOCs TAL metals	EPA CLP SOW OLM03.1 EPA CLP SOW OLM03.1 EPA CLP SOW ILM04.0	38 (20 test pits in filled area)	2 duplicates 3 rinsate blanks
	Methyl mercury	Bloom (1989) and Liang (1994)	7	1 rinsate blank
Discretionary Samples from Test Pits	TAL metals	EPA CLP SOW ILM04.0	9	None
	Sulfate	EPA 375.4		

TABLE 2-1. (cont.)

Component of Field Investigation	Analytes	Method Reference ^a	Number of Sample Locations (breakdown by area of Site)	QA/QC Samples
Groundwater	TCL VOCs	EPA CLP SOW OLM03.1	12 (4 developed area, 8 filled area)	1 duplicate 6 rinsate blanks 4 trip blanks
	TCL SVOCs	EPA CLP SOW OLM03.1		
	TAL metals	EPA CLP SOW ILM04.0		
	Methyl mercury	Bloom (1989) and Liang (1994)		
	TPH	EPA Method 418.1M		
	TDS	EPA Method 160.1		
	Chloride	EPA 325.3		
	Sulfate	EPA 375.4		
	Alkalinity	EPA 310.1		
	Orthophosphate	EPA 365.1		
	BOD	EPA 405.1		
	COD	EPA 410.4		
Seeps	TCL VOCs	EPA CLP SOW OLM03.1	5 (3 from Berry's Creek bank, 2 from ditch banks)	1 duplicate 2 rinsate blanks 2 trip blanks
	TCL SVOCs	EPA CLP SOW OLM03.1		
	TAL metals	EPA CLP SOW ILM04.0		
	TAL metals (filtered)	EPA CLP SOW ILM04.0		
	Methyl mercury	Bloom (1989) and Liang (1994)		
	Methyl mercury (filtered)	Bloom (1989) and Liang (1994)		
	TPH	EPA Method 418.1M		
	TDS	EPA Method 160.1		
Surface Water	TCL VOCs	EPA CLP SOW OLM03.1	17 (12 from Berry's Creek: 4 locations during three tidal periods; 3 from ditch; 2 from pond)	1 duplicate 2 rinsate blanks 1 trip blank
	TCL SVOCs	EPA CLP SOW OLM03.1		
	TAL metals	EPA CLP SOW ILM04.0		
	TAL metals (filtered)	EPA CLP SOW ILM04.0		
	Methyl mercury	Bloom (1989) and Liang (1994)		
	Methyl mercury (filtered)	Bloom (1989) and Liang (1994)		
	TPH	EPA Method 418.1M		
	TDS	EPA Method 160.1		
	Hardness	EPA Method 130.2		

TABLE 2-1. (cont.)

Component of Field Investigation	Analytes	Method Reference ^a	Number of Sample Locations (breakdown by area of Site)	QA/QC Samples
Sediment	TCL VOCs	EPA CLP SOW OLM03.1	9 (4 from Berry's Creek; 3 from ditch; 2 from pond)	1 duplicate, 1 rinsate blank
	TCL SVOCs	EPA CLP SOW OLM03.1		
	TCL PCBs	SW-846 Method 8080A		
	TAL metals	EPA CLP SOW ILM04.0		
	Methyl mercury	Bloom (1989) and Liang (1994)		
	TPH	EPA Method 418.1M		
	TOC	SW-846 Method 9060		
	Grain Size	ASTM D422		
Air	Mercury vapor	Bloom et al. 1995	1 st round: 5	3 trip blanks
	Mercury particulates	Bloom and Fitzgerald 1998	(4 developed area, 1 filled area)	
			2 nd round: 6 (6 filled area)	1 trip blank
Hazardous Substance Inventory -Drummed Waste -Surface Samples	TCLP VOCs ^b	SW-846 Method 8260A	10 total: 3 drums from test pits analyzed for full characterization 3 surface drums analyzed for TAL metals only 4 surface samples analyzed for TAL metals only	1 rinsate blank 1 trip blank
	TCLP SVOCs ^b	SW-846 Method 8270B		
	TCLP PCBs ^b	SW-846 Method 8081		
	Organochlorine pesticides	SW-846 Method 8081		
	Chlorinated herbicides	SW-846 Method 8150B		
	Phenols	SW-846 Method 9065		
	TCLP metals ^b	SW-846 Methods 6010A /7000-series		
	Free liquids	Visual inspection		
	Specific gravity	Volume and weight measurements		
	pH	SW-846 Method 9040A		
	Cyanide	SW-846 Method 9010A/9012		
	Sulfide	SW-846 Method 9030A		
	Reactivity (as reactive cyanide and sulfide)	SW-846, Chapter 7		
	Corrosivity	SW-846 Method 1110		
	Ignitability	SW-846 Method 1010 or 1020		

Notes: TCL - target compound list VOCs - volatile organic compounds SVOCs - semivolatile organic compounds
TAL - target analyte list CLP - Contract Laboratory Program SOW - statement of work
OLM - organic laboratory methods ILM - inorganic laboratory methods TPH - total petroleum hydrocarbons
TDS - total dissolved solids BOD - biological oxygen demand COD - chemical oxygen demand
PCBs - polychlorinated biphenyls EPA - U.S. Environmental Protection Agency
ASTM - American Society for Testing and Materials TCLP - toxicity characteristic leaching procedure

^a Complete method references are included in Section 9.

^b For the analysis of TCLP VOC, SVOC, and metals, results for TCL VOC, SVOC, and metals are also be reported.

TABLE 3-1. SUMMARY OF GROUNDWATER ELEVATION MEASUREMENTS

Monitoring Well	Elevation of Measuring Point	October 15, 1997		December 9, 1997		January 15, 1998	
		Depth to Water	Ground Water Elevation	Depth to Water	Ground Water Elevation	Depth to Water	Ground Water Elevation
MW-1	11.36	8.89	2.47	8.51	2.85	7.9	3.46
MW-1A	9.15	6.53	2.62	6.44	2.71	NA	NA
MW-2	12.94	10.62	2.32	10.02	2.92	9.49	3.45
MW-3	12.32	9.84	2.48	9.32	3.	8.81	3.51
MW-4	9.89	NA	NA	7.22	2.67	6.82	3.07
MW-4A	11.55	8.72	2.83	9.09	2.46	NA	NA
MW-5	10.7	9.18	1.52	8.5	2.2	8.09	2.61
MW-6	12.12	11.98	.14	11.34	.78	10.88	1.24
MW-7	7.19	5.65	1.54	4.45	2.74	3.85	3.34
MW-8	8.1	6.68	1.42	5.88	2.22	5.37	2.73
MW-9	6.6	6.26	.34	5.08	1.52	4.24	2.36
MW-10	6.52	2.3	4.22	.84	5.68	1.14	5.38
MW-11	4.83	1.62	3.21	1.7	3.13	.36	4.47
MW-12	7.73	5.44	2.29	5.42	2.31	4.87	2.86
MW-12A	7.56	5.51	2.05	7.18	.38	NA	NA
Upstream ¹	9.13	NA	NA	10.6	- 1.47	10.77	- 1.64
Downstream ²	9.13	NA	NA	7.58	1.55	7.56	1.57

Notes: Elevations in feet above mean sea level

Depth to water measurements in feet

NA - Not available

¹ Surface water measuring point upstream of tide gate on Berry's Creek

² Surface water measuring point downstream of tide gate on Berry's Creek

TABLE 3-2. RISING-HEAD SLUG TEST RESULTS

Monitoring Well	Hydraulic Conductivity from Test No. 1 (ft/min)	Hydraulic Conductivity from Test No. 2 (ft/min)	Average
MW-1	0.036	0.044	0.04
MW-2	0.0032	0.0033	0.0033
MW-3	0.027	0.028	0.028
MW-4	0.056	0.075	0.066
MW-5	0.0049	0.0048	0.0049
MW-6	0.00016	not measured ^a	0.00016
MW-7	0.0012	0.0016	0.0014
MW-8	0.0099	0.0083	0.0091
MW-9	0.0017	0.0018	0.0018
MW-10	0.005	0.0051	0.0051
MW-11	0.0041	0.0033	0.0037
MW-12	0.0034	0.0033	0.0034

^a See discussion in text

**TABLE 3-3. PLANT SPECIES OBSERVED
AT THE VENTRON/VELSICOL SITE**

Common name	Scientific Name
Arrow arum	<i>Peltandra virginica</i>
Arrow-wood	<i>Viburnum dentatum</i>
Bittersweet	<i>Celastrus</i> sp.
Black gum	<i>Nyssa sylvatica</i>
Black locust	<i>Robinia pseudo-acacia</i>
Black willow	<i>Salix nigra</i>
Catbrier	<i>Smilax glauca</i>
Choke cherry	<i>Prunus virginiana</i>
Cleavers	<i>Galium aparine</i>
Common elderberry	<i>Sambucus canadensis</i>
Common reed	<i>Phragmites australis</i>
Dwarf sumac	<i>Rhus copallinum</i>
Eastern cottonwood	<i>Populus deltoides</i>
Eastern red cedar	<i>Juniperus virginiana</i>
Elm	<i>Ulmus</i> sp.
Fox grape	<i>Vitis labrusca</i>
Garlic mustard	<i>Brassica</i> sp.
Goldenrod	<i>Solidago canadensis</i>
Gray birch	<i>Betula populifolia</i>
Groundsel-tree	<i>Baccharis halimifolia</i>
Iris	<i>Iris</i> sp.
Japanese honeysuckle	<i>Lonicera japonica</i>
Japanese knotweed	<i>Polygonum cuspidatum</i>
Jewel weed	<i>Impatiens capensis</i>
Mugwort	<i>Artemisia vulgaris</i>
Mulberry	<i>Morus</i> sp.
Multiflora rose	<i>Rosa multiflora</i>
Pennsylvania smartweed	<i>Polygonum pennsylvanicum</i>
Pickering-weed	<i>Pontederia cordata</i>
Pin oak	<i>Quercus palustris</i>
Poison ivy	<i>Toxicodendron radicans</i>
Poplar	<i>Populus tremuloides</i>
Princess tree	<i>Paulownia tomentosa</i>
Red maple	<i>Acer rubrum</i>
Russian olive	<i>Elaeagnus angustifolia</i>
Sassafras	<i>Sassafras albidum</i>
Sensitive fern	<i>Onoclea sensibilis</i>
Silver maple	<i>Acer saccharinum</i>
Smooth cordgrass	<i>Spartina alterniflora</i>
Sweet gum	<i>Liquidambar styraciflua</i>
Tree-of-heaven	<i>Ailanthus altissima</i>

Note: Table based on information in Shisler (1997) and from field observations in 1998.

**TABLE 3-4. WILDLIFE SPECIES OBSERVED
AT THE VENTRON/VELSICOL SITE**

Common name	Scientific Name
Birds	
American crow	<i>Corvus brachyrhynchos</i>
American robin	<i>Turdus migratorious</i>
Blue jay	<i>Cyanocitta cristata</i>
Canada goose	<i>Branta canadensis</i>
Catbird	<i>Dumetella carolinensis</i>
Common flicker	<i>Colaptes auratus</i>
Common grackle	<i>Quiscalus quiscula</i>
Eastern kingbird	<i>Tyrannus tyrannus</i>
English sparrow	<i>Passer domesticus</i>
European starling	<i>Sturnus vulgaris</i>
Mallard duck	<i>Anas platyrhynchos</i>
Mockingbird	<i>Mimus polyglottos</i>
Mourning dove	<i>Zenaidura macroura</i>
Northern cardinal	<i>Picoides villosus</i>
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>
Red-winged blackbird	<i>Agelaius phoeniceus</i>
Spotted sandpiper	<i>Actitis macularia</i>
Tree swallow	<i>Iridoprocne bicolor</i>
Warbler	<i>Dendroica spp.</i>
Mammals	
Cat	<i>Felis domesticus</i>
Cottontail rabbit	<i>Sylvilagus spp.</i>
Eastern chipmunk	<i>Tamias striatus</i>
Eastern gray squirrel	<i>Sciurus carolinensis</i>
Muskrat	<i>Ondatra zibethicus</i>
Norway rat	<i>Rattus norvegicus</i>
Opossum	<i>Didelphis virginiana</i>
Wood chuck	<i>Marmota monax</i>
Herptiles	
Snapping turtle	<i>Chelydra serpentina</i>

Note: Table based on information field observations in 1997 and 1998.

TABLE 3-5. FEEDING HABITS OF BIRDS OBSERVED AT VENTRON/VELSICOL SITE

Common name	% Diet Plant ^a				Site-specific Resource Attributes ^b		
	W	Sp	Su	F	Type (plant species)	Abundance (qualitative est.)	Value (% of diet)
Common grackle	84%	52%	45%	82%	oak	low	5–10%
Tree swallow	30%	1%	21%	29%	red cedar	low	2–5%
Blue jay	91%	68%	54%	77%	oak	low	25–50%
English sparrow	99%	91%	94%	98%	knotweed	low-medium	2–5%
Red-winged blackbird	95%	60%	50%	91%	smartweed	low	5–10%
Starling	68%	7%	41%	39%	cherry	low	5–10%
American robin	64%	21%	60%	81%	cherry	low	10–25%
					sumac	low	5–10%
					black gum	low	5–10%
					grape	low	2–5%
					red cedar	low	2–5%
					sumac	low	5–10%
					elderberry	low	2–5%
					poison ivy	low	2–5%
					mulberry	low	2–5%
Mockingbird ^c	59%	17%	35%	67%	red cedar	low	2–5%
					grape	low	2–5%
					elderberry	low	2–5%
					sumac	low	2–5%
					mulberry	low	2–5%
Catbird	76%	20%	60%	81%	cherry	low	5–10%
					elderberry	low	2–5%
					grape	low	2–5%
					sumac	low	2–5%
					sassafras	low	2–5%
Warbler ^d	17%	<1%	0%	63%	red cedar	low	2–5%
					poison ivy	low	2–5%
Common flicker	63%	8%	23%	55%	poison ivy	low	10–25%
					cherry	low	2–5%
Kingbird	0%	2%	18%	36%	sassafras	low	2–5%
					cherry	low	2–5%
Red-headed woodpecker	91%	34%	37%	72%	oak	low	10–25%
					cherry	low	2–5%
					mulberry	low	2–5%
Mourning doves	99%	99%	99%	99%	knotweed	low-medium	2–5%

^a Percent diet plant values are based on stomach analysis studies cited in Martin et al., 1961.

^b Site-specific attributes are related to field observations of vegetative resources (e.g., vegetation type and abundance at site (e.g., low, medium, high). Resource value is shown as a function of % use in the bird's diet (Martin et al. 1961).

^c Data related to diet are specific to southeastern mockingbirds.

^d Data related to diet are specific to the *Myrtle* genus of warblers.

TABLE 3-6. FEEDING HABITS OF MAMMALS AT VENTRON/VELSICOL SITE

Common name	% Diet Plant ^a				Site-specific Resource Attributes ^b		
	W	Sp	Su	F	Type (plant species)	Abundance (qualitative est.)	Value (% of diet)
Wood chuck	100%	100%	100%	100%	herbaceous plants	high	NA
Opossum	17%	5%	13%	17%	grape	low	2–5%
Cottontail rabbit	100%	100%	100%	100%	herbaceous plants	high	NA
Eastern chipmunk	97%	69%	87%	91%	maple	low	5–10%
					oak	low	5–10%
					cherry	low	2–5%
Eastern gray squirrel	98%	100%	87%	98%	oak	low	25–50%
					maple	low	5–10%
					mulberry	low	2–5%
Muskrat ^c	98%	98%	98%	98%	cattail	low	25–50%
					common reed	high	NA
					pondweed	low	2–5%
					arrowhead	low	2–5%

NA = Not available.

^a Percent (%) diet plant values are based on stomach analysis studies cited in Martin et al. 1961.

^b Site-specific attributes are related to field observations of vegetative resources (e.g., vegetation type and abundance) at the site (e.g., low, medium, high). Resource value is shown as a function of % use in the mammal's diet (Martin et al. 1961)

^c Although muskrats eat primarily vegetation, a trace amount of their diets may include aquatic invertebrates.

TABLE 3-7. WETLAND FUNCTIONAL ASSESSMENT ATTRIBUTES

Category	Rating	Rationale
WILDLIFE HABITAT ATTRIBUTES		
Aquatic Diversity and Abundance	2.0	The dense stand of <i>Phragmites</i> limits the abundance of aquatic species that use the Site. The dense <i>Phragmites</i> extends to the water's edge and does not provide space for other vegetation to colonize. The lack of emergent and submerged aquatic species along the Diamond Shamrock/Henkel ditches limits wildlife habitats and access to the Site.
General Fish Habitat	2.0	Rationale: Fish habitats on the site have a low diversity as a result of the dense <i>Phragmites</i> stands. Fish habitat is limited to Berry's Creek and the two Diamond Shamrock/Henkel ditches. The wetland surface is accessible to fish only during spring tides and storm events.
General Waterfowl Habitat	2.0	The dense growth of <i>Phragmites</i> inhibits waterfowl use of the wetlands for nesting or resting. Waterfowl use of Berry's Creek and the Diamond Shamrock/Henkel ditches is limited to a few resident and migratory species.
General Wildlife Habitat	2.0	The <i>Phragmites</i> -dominated community does not provide a diverse wildlife habitat. Berry's Creek and the Diamond Shamrock/Henkel ditches in the marsh area provide water-based wildlife habitat. These open-water systems do not support emergent or submergent vegetation communities that are the preferred habitats for most water-dependent bird species. The wetland area may be used by a few passerine species and perhaps one or two mammal species.
Production Export	3.0	The dense vegetation will be exported from the Site, but the diversity is low as a result of the dominance of <i>Phragmites</i> in the marsh area. The exported material could be used in the Berry's Creek and Hackensack River Watershed.
Overall Wildlife Habitat	2.2	The dense monoculture of <i>Phragmites</i> limits the wildlife habitat on the Site, especially for waterfowl and wildlife. The low species diversity and production on the Site limit its contribution to the adjacent areas. The wetland areas are poor habitats for wildlife.

TABLE 3-7. (cont.)

Category	Rating	Rationale
WATER QUALITY IMPROVEMENT ATTRIBUTES		
Nutrient Removal/ Transformation	4.0	The existing <i>Phragmites</i> -dominated community on the Site is only completely inundated by Berry's Creek during spring tides and storm events. The dense <i>Phragmites</i> stand acts both as a physical and chemical trapping mechanism, providing a high value during these events.
Sediment/Toxicant Retention	4.0	The elevation of the <i>Phragmites</i> -dominated community is above normal tidal inundation. The ability to retain sediment is greatest when the marsh area is inundated during spring tides and storm events.
Overall Water Quality Improvement	4.0	The dense growth of <i>Phragmites</i> will function to improve water quality during spring tides and storm events.
SOCIAL SIGNIFICANCE ATTRIBUTES		
Recreational	0.0	The area is privately owned at present, which prohibits recreational use of the Site.
Flood Flow Alteration	8.0	The wetlands absorb and retain tidal/storm overflows from Berry's Creek.
Conservation Potential	1.0	Conservation potential is very low because of limited wildlife habitat and lack of recreational use of the Site. The marsh area is surrounded by water, and industrial and commercial properties, greatly limiting Site access.
Overall Social Significance	3.0	The major functions of the wetlands are flood-flow alteration and water quality improvement. There is no real potential for recreation and/or conservation uses of the marsh area.

TABLE 4-1. SUMMARY OF SoPCs IN ONSITE SURFACE SOILS

Analyte	Units (dry wt.)	Developed Area (n=9)				Undeveloped Filled Area (n=24)				Marsh Area (n=19)			
		Geometric	Minimum	Maximum	No. of Undetects	Geometric	Minimum	Maximum	No. of Undetects	Geometric	Minimum	Maximum	No. of Undetects
		Mean				Mean				Mean			
Mercury													
Total	mg/kg	317	9.3	13,800	0	39.3	1.2	548	0	166	25.1	1,090	0
Methyl	mg/kg	ND ^a	ND ^a	ND ^a	ND ^a	0.005	0.0006	0.322	0 ^a	0.033	0.004	0.233	0
Metals													
Arsenic	mg/kg	4.78	3.1	11	3	7.83	4.3	14.3	4	36.6	15.6	150	1
Beryllium	mg/kg	0.68	0.68	0.68	8	0.35	0.35	0.35	23	0.82	0.82	0.82	18
Cadmium	mg/kg	0.894	0.22	3.1	4	3.1	0.25	21.2	9	16.2	3.8	68.3	0
Chromium	mg/kg	15.9	6.6	96.9	0	59.5	11.3	1,150	0	796	142	2,170	0
Copper	mg/kg	62.2	12.4	470	0	152	22.8	1,010	0	297	44.2	730	0
Iron	mg/kg	9,944	3,860	23,000	0	21,007	5,530	122,000	0	24,107	7,060	35,300	0
Lead	mg/kg	71.4	17.8	390	0	430	39.3	4,320	0	248	51.6	401	0
Manganese	mg/kg	231	110	540	0	293	66.3	3,090	0	5,781	112	27,500	0
Nickel	mg/kg	17.4	4.65	72.2	2	34.6	11.4	81.7	2	119	18.2	274	0
Silver	mg/kg	1.29	0.56	7.65	4	2.73	0.54	93.8	3	5.29	2.1	9.6	2
Sodium	mg/kg	630	630	630	8	1374	592	2,580	21	2,988	354	10,200	0
Thallium	mg/kg	ND	ND	ND	9	17.8	14.5	21.9	22	11.5	6.2	24.4	9
Zinc	mg/kg	371	88.9	1,100	0	1,312	192	25,400	6	3,073	868	22,700	0
Semivolatile Organic Compounds													
Anthracene	µg/kg	114	40	460	2	222	45	4,100	8	323	95	1,100	17
Benz[a]anthracene	µg/kg	397	150	1,400	2	491	78	4,000	2	338	130	5,800	0
Benzo[a]pyrene	µg/kg	356	120	1,100	2	544	73	10,000	2	427	150	4,900	0
Benzo[b]fluoranthene	µg/kg	433	73	1,400	1	875	160	13,000	5	610	230	7,100	0
Benzo[g,h,i]perylene	µg/kg	216	96	520	2	339	48	2,200	2	377	100	2,700	0
Benzo[k]fluoranthene	µg/kg	137	43	300	1	338	68	4,700	5	236	120	1,600	7
Bis[2-ethylhexyl]phthalate	µg/kg	1,374	310	8,600	1	4,327	460	380,000	11	1,077	87	3,500	5
Chrysene	µg/kg	346	56	1,400	1	644	90	12,000	2	451	160	5,600	0
Dibenz[a,h]anthracene	µg/kg	81	50	150	4	150	44	900	8	136	110	170	12
Fluoranthene	µg/kg	445	39	2,600	0	957	120	26,000	2	614	220	10,000	0
Fluorene	µg/kg	100	41	370	2	151	55	1,100	16	290	290	290	18
Indeno[1,2,3-cd]pyrene	µg/kg	194	75	470	2	353	57	2,600	3	353	95	3,200	0
Phenanthrene	µg/kg	475	160	2,500	2	526	59	16,000	2	327	100	4,100	7
Pyrene	µg/kg	432	43	2,600	0	790	42	24,000	1	611	240	9,000	0

Medium-specific SoPCs are highlighted

ND = Not detected

^a Methylmercury was not analyzed for in the developed area (i.e., n=0), and only 9 samples in the undeveloped area were analyzed for methylmercury (i.e., n=9)

TABLE 4-2. SUMMARY OF SoPCs IN SUBSURFACE SOIL

Analyte	Units (dry wt.)	On-Site Test Pits (n=38)			No. of Undetects
		Geometric Mean	Minimum	Maximum	
Mercury					
Total	mg/kg	34.9	0.26	34,700	0
Methyl	mg/kg	0.00070	0.00008	0.00446	0 ^a
Metals					
Arsenic	mg/kg	9.79	1.4	120	1
Beryllium	mg/kg	1.52	1.1	2.1	36
Cadmium	mg/kg	3.4	0.4	36.1	0
Chromium	mg/kg	66.5	6.4	606	0
Copper	mg/kg	181	6.73	2,190	0
Iron	mg/kg	29,605	1,840	293,000	0
Lead	mg/kg	518	5.9	3,830	0
Manganese	mg/kg	306	16.5	23,300	0
Nickel	mg/kg	46.6	8.2	317	0
Silver	mg/kg	2.21	0.16	84.8	5
Sodium	mg/kg	236	63	2,780	18
Thallium	mg/kg	11.5	9.4	12.9	35
Zinc	mg/kg	1,010	41.5	43,200	0
Semivolatile Organic Compounds					
Anthracene	µg/kg	185	46	27,000	15
Benzo[a]anthracene	µg/kg	469	55	49,000	10
Benzo[a]pyrene	µg/kg	539	72	49,000	12
Benzo[b]fluoranthene	µg/kg	715	74	84,000	10
Benzo[ghi]perylene	µg/kg	249	50	9,500	10
Benzo[k]fluoranthene	µg/kg	334	44	9,100	0
Bis[2-ethylhexyl]phthalate	µg/kg	621	58	14,000	6
Chrysene	µg/kg	504	46	30,000	9
Dibenz[a,h]anthracene	µg/kg	109	53	1,300	19
Fluoranthene	µg/kg	708	53	130,000	8
Fluorene	µg/kg	235	55	16,000	28
Indeno[1,2,3-cd]pyrene	µg/kg	257	45	12,000	13
Phenanthrene	µg/kg	465	74	81,000	11
Pyrene	µg/kg	491	51	86,000	7

Medium-specific SoPCs are highlighted

^a Methylmercury was analyzed for in only 7 samples (i.e., n=7)

TABLE 4-3. SUMMARY OF SoPCs IN OFFSITE SURFACE SOIL

Analyte	Units (dry wt.)	Adjacent to Site (n=8)				Not adjacent to Site (n=14)			
		Geometric Mean	Minimum	Maximum	No. of Undetects	Geometric Mean	Minimum	Maximum	No. of Undetects
Mercury									
Total	mg/kg	32.3	5.16	554	0	3.83	0.535	16.6	2
Metals									
Cadmium	mg/kg	0.792	0.078	2.98	0	0.376	0.119	2.57	1
Copper	mg/kg	63	15.7	202	0	47.1	13.5	120	0
Lead	mg/kg	129	23	410	0	84.6	3.61	392	0
Thallium	mg/kg	ND	ND	ND	8	ND	ND	ND	14
Zinc	mg/kg	247	86.8	459	0	149	26.9	777	0
Semivolatile Organic Compounds									
Benz[a]anthracene	µg/kg	627	77	2,300	0	887	140	15,000	1
Benzo[a]pyrene	µg/kg	633	67	2,200	0	1,022	200	18,000	1
Benzo[b]fluoranthene	µg/kg	971	130	2,800	0	1,479	310	22,000	1
Benzo[k]fluoranthene	µg/kg	401	210	820	1	527	110	11,000	1
Bis[2-ethylhexyl]phthalate	µg/kg	181	77	490	1	127	44	260	9
Dibenz[a,h]anthracene	µg/kg	85	62	120	4	180	39	2,100	5
Indeno[1,2,3-cd]pyrene	µg/kg	399	220	720	1	566	110	6,800	3

Medium-specific SoPCs are highlighted

ND = None detected

TABLE 4-4. REPORTED BACKGROUND CONCENTRATIONS OF METALS AND SVOCs IN SOILS

	NJDEP ^a	Rutgers ^b	Bradley <i>et al.</i> ^c
Mercury			
Mercury	0.2 mg/kg	--	0.19-0.29 mg/kg
Metals			
Arsenic	5.49 mg/kg	--	3.53-5.63 mg/kg
Beryllium	0.86 mg/kg	--	--
Cadmium	0.5 mg/kg	0.24 mg/kg	1.55 mg/kg
Chromium	11.2 mg/kg	19.9 mg/kg	12.1-23 mg/kg
Copper	32.8 mg/kg	15.6 mg/kg	--
Iron	--	--	--
Lead	113 mg/kg	28.6 mg/kg	262-399 mg/kg
Manganese	283 mg/kg	553 mg/kg	--
Nickel	14.1 mg/kg	20.9 mg/kg	--
Silver	0.16 mg/kg	--	--
Sodium	--	--	--
Thallium	0.07 mg/kg	--	--
Zinc	116 mg/kg	71.3 mg/kg	--
Volatile Organic Compounds			
Benzene	--	--	--
Chlorobenzene	--	--	--
Toluene	--	--	--
Xylene isomers (total)	--	--	--
Semi-Volatile Organic Compounds			
Anthracene	--	--	351 µg/kg
Benz[a]anthracene	--	--	1319 µg/kg
Benzo[a]pyrene	--	--	1323 µg/kg
Benzo[b]fluoranthene	--	--	1435 µg/kg
Benzo[g,h,i]perylene	--	--	891 µg/kg
Benzo[k]fluoranthene	--	--	1681 µg/kg
Bis[2-ethylhexyl]phthalate	--	--	--
Chrysene	--	--	1841 µg/kg
Dibenz[a,h]anthracene	--	--	388 µg/kg
Fluoranthene	--	--	3047 µg/kg
Fluorene	--	--	214 µg/kg
Indeno[1,2,3-cd]pyrene	--	--	987 µg/kg
Phenanthrene	--	--	1838 µg/kg
Pyrene	--	--	2398 µg/kg
PCBs			
Aroclor(R) 1248	--	--	--
Aroclor(R) 1260	--	--	--

Notes:^aGeometric means reported are background concentrations for NJ urban surface soils (NJDEP 1993b).^bArithmetic means reported represent compilation of data over many years by H.L. Motto, Department of Environmental Sciences, Rutgers University (NJDEP 1993b).^cBradley, *et al.* (1994) report arithmetic means of background levels for PAHs in New England urban soils.

Reported metal values are the ranges of means found in three New England cities.

-- No background value for compound.

TABLE 4-5. SUMMARY OF SoPCs IN GROUNDWATER

Analyte	Units	Developed Area (n=4)				Undeveloped Filled Area (n=8)			
		Geometric	Minimum	Maximum	No. of Undetects	Geometric	Minimum	Maximum	No. of Undetects
		Mean				Mean			
Mercury									
Total	µg/L	0.770	0.5	1.2	1	2.16	0.57	8.20	6
Methyl	µg/L	0.00150	0.00014	0.00561	0	0.00340	0.00044	0.02	0
Metals									
Arsenic	µg/L	2.6	2.6	2.6	3	13.8	13.8	13.8	7
Beryllium	µg/L	ND	ND	ND	4	0.55	0.55	0.55	7
Cadmium	µg/L	2.5	2.5	2.5	3	1.1	1.1	1.1	7
Chromium	µg/L	ND	ND	ND	4	2.44	1.3	6.8	3
Cobalt	µg/L	1.16	0.94	1.4	1	1.99	1.1	3.9	1
Copper	µg/L	2.33	1.7	3.2	2	3.17	2	4.3	3
Iron	µg/L	2,218	152	37,500	0	11,942	1,160	33,000	0
Lead	µg/L	ND	ND	ND	4	1.10	1	1.2	6
Manganese	µg/L	431	74.1	2,620	0	938	361	3840	0
Nickel	µg/L	3.93	2.1	7.4	0	7.51	3.4	116	0
Silver	µg/L	ND	ND	ND	4	ND	ND	ND	8
Sodium	µg/L	46,956	31,700	83,800	0	74,481	42,000	485,000	0
Thallium	µg/L	ND	ND	ND	4	5	5	5	7
Zinc	µg/L	23.0	12.5	48.2	0	78.2	12.3	589	0
Volatile Organic Compounds									
Benzene	µg/L	ND	ND	ND	4	50.2	18	140	6
Chlorobenzene	µg/L	ND	ND	ND	4	5.10	3	15	4
Toluene	µg/L	ND	ND	ND	4	1,700	1,700	1,700	7
Xylene Isomers (total)	µg/L	ND	ND	ND	4	390	390	390	7

Medium-specific SoPCs are highlighted

ND = None detected

TABLE 4-6. CHARACTERISTIC VALUES OF LANDFILL LEACHATE IN GROUNDWATER

Analyte	Units	Miller (1980) ^a			Bouwer (1978) ^b			EPA (1988b) ^c			
		minimum	maximum	median	normal range		upper limits	minimum	maximum	median	average
					minimum	maximum					
Metals											
Arsenic	µg/L	—	—	—	—	—	—	0.2	982	13.5	41.8
Beryllium	µg/L	—	—	—	—	—	—	1	10	4.75	5.6
Cadmium	µg/L	—	—	—	—	—	—	0.7	150	13.5	22
Chromium	µg/L	—	—	—	—	—	—	0.5	1,900	60	175.4
Copper	µg/L	0	9,900	500	100	9,000	9,900	3	2,800	54	167.9
Iron	µg/L	0	2,820,000	94,000	100	1,700,000	5,500,000	220	2,280,000	95,150	221,000
Lead	µg/L	100	2,000	750	—	—	5,000	5	1,600	63	161.6
Manganese	µg/L	60	125,000	220	—	—	1,400,000	30	79,000	3,700	9,590
Total mercury	µg/L	—	—	—	—	—	—	0.1	9.8	0.6	2
Nickel	µg/L	—	—	—	10	800	—	20	2,227	170	325.5
Silver	µg/L	—	—	—	—	—	—	0.8	50	20	20.8
Thallium	µg/L	—	—	—	—	—	—	4	860	80	175.3
Zinc	µg/L	0	370,000	3,500	30	135,000	1,000,000	30	350,000	675	8,320
Conventional Analytes											
Biochemical oxygen demand	mg/L	81	33,360	5,700	21,700	30,300	54,610	7	29,200	2,310	3,837
Carbonate alkalinity	mg/L	0	20,850	3,050	730	9,500	20,850	470	57,850	2,650	4,214
Chemical oxygen demand	mg/L	40	89,520	8,100	100	51,000	89,250	42	50,450	2,800	4,773
Orthophosphate-phosphorus	mg/L	—	—	—	0.3	130	472	—	—	—	—
Petroleum hydrocarbons	mg/L	—	—	—	—	—	—	—	—	—	—
Sulfate	mg/L	1	1,558	47	20	730	1,826	8	1,400	111	244
Total chloride	mg/L	4.7	2,500	700	47	2,400	2,800	31	5,475	594	786
Total dissolved solids	mg/L	584	44,900	8,955	—	—	42,276	390	31,800	4,890	5,691
Total phosphate	mg/L	0	130	10.1	—	—	—	0.42	8.7	1.2	2.67

Notes:

^aSummary of leachate characteristics based on 20 samples from municipal solid wastes

^bChemical composition of landfill leachate

^cStatistical Summary of Indicator Parameters in MSWLF leachate (and other inorganics)

TABLE 4-7. SUMMARY OF SoPCs IN SEEPS

Analyte	Units	Sample Location and Date of Sample Collection				
		SE-01	SE-02	SE-03	SE-04*	SE-06
		SE0001 10/15/97	SE0002 10/15/97	SE0003 10/15/97	SE0004/5 10/15/97	SE0006 10/15/97
Mercury						
Total - Filtered	µg/L	0.2 <i>u</i>	0.2 <i>u</i>	0.2 <i>u</i>	0.32 **	1.80
Total - Unfiltered	µg/L	104.00 <i>J</i>	2.10 <i>J</i>	24.50 <i>J</i>	21.10	24.10
Methyl - Filtered	µg/L	0.00011	0.00031	0.00153	0.00222	0.00028
Methyl - Unfiltered	µg/L	0.00074	0.01004	0.0218	0.0331	0.0097
Total - Particulate ^c	mg/kg	206	10.3	158	149	94.9
Methyl - Particulate ^c	mg/kg	0.00125	0.04793	0.13090	0.22140	0.04009
Filtered Metals						
Arsenic	µg/L	2.4	2.2 <i>u</i>	2.2 <i>u</i>	2.2 <i>u</i>	2.20
Beryllium	µg/L	0.27 <i>u</i>	0.29 <i>U</i>	0.27 <i>u</i>	0.40 <i>U</i>	0.47 <i>U</i>
Cadmium	µg/L	0.44 <i>u</i>	5.60	0.44 <i>u</i>	0.76 <i>u</i>	1.10 <i>U</i>
Chromium	µg/L	0.56 <i>u</i>	0.56 <i>u</i>	0.56 <i>u</i>	0.56 <i>u</i>	0.56 <i>u</i>
Copper	µg/L	3.0 <i>J</i>	19.80 <i>J</i>	4.00 <i>J</i>	2.10 <i>J</i>	13.10 <i>J</i>
Iron	µg/L	9.4 <i>u</i>	217	141	524	150
Lead	µg/L	0.8 <i>u</i>	0.8 <i>u</i>	0.8 <i>u</i>	0.8 <i>u</i>	1.40
Manganese	µg/L	794	503	1660	1400	200
Nickel	µg/L	41.3	27	9.00	11.30	13.40
Silver	µg/L	0.73 <i>u</i>	.84 <i>U</i>	0.73 <i>u</i>	1.2 <i>u</i>	0.73 <i>u</i>
Sodium	µg/L	1,610,000	1,550,000	1,390,000	74,200	1,240,000
Thallium	µg/L	6.9 <i>U</i>	8.60 <i>U</i>	6.90 <i>U</i>	6.40 <i>U</i>	10.80 <i>U</i>
Zinc	µg/L	1,460	897	52.8	146	366
Unfiltered Metals						
Arsenic	µg/L	30	2.2 <i>u</i>	9.10	4.20 **	4.50
Beryllium	µg/L	0.40 <i>U</i>	0.27 <i>u</i>	0.27 <i>u</i>	.33 <i>U</i>	0.27 <i>u</i>
Cadmium	µg/L	23.3	6.9	3.0	3.70 **	2.20 <i>U</i>
Chromium	µg/L	431	13.8	96	24.2	12.2
Copper	µg/L	279 <i>J</i>	58.8 <i>J</i>	82 <i>J</i>	40.2 <i>J</i>	31.5 <i>J</i>
Iron	µg/L	23,600	3,400	11,800	14,400	1,430
Lead	µg/L	219	10.5	58.1	29.9	103
Manganese	µg/L	1,650	479	1770	1200	295
Nickel	µg/L	84.1	28.4	19.5	7.30	13.9
Silver	µg/L	3.50 <i>U</i>	2.60 <i>U</i>	2.10 <i>U</i>	0.90 <i>U</i>	13.5
Sodium	µg/L	1,580,000	1,420,000	1,270,000	240,000	1,180,000
Thallium	µg/L	7.10 <i>U</i>	7.50 <i>U</i>	6.20 <i>U</i>	7.10 <i>U</i>	7.90 <i>U</i>
Zinc	µg/L	26,900	985	311	370	442
Other Parameters						
Total suspended solids	mg/L	505	203	155	140	235

Medium-specific SoPCs are highlighted

u = The compound was analyzed for but not detected

J = Estimated concentration

* Average of field duplicates

** Single value reported only; duplicate was not detected

^a Particulate concentrations calculated by subtracting filtered values from unfiltered values and dividing that value by the TSS value

TABLE 4-8. SUMMARY OF SoPCs IN SURFACE WATER

Analyte	Units	Sample Location and Date of Sample Collection					
		SW-01	SW-01	SW-01	SW-02	SW-02*	SW-02
		SW0008	SW0012	SW0016	SW0007	SW0011/17	SW0015
		10/31/97	10/31/97	10/31/97	10/31/97	10/31/97	10/31/97
		HIGH TIDE	MID TIDE	LOW TIDE	HIGH TIDE	MID TIDE	LOW TIDE
Mercury							
Total - Filtered	µg/L	0.2 <i>u</i>	0.2 <i>u</i>	0.2 <i>u</i>	0.2 <i>u</i>	0.2 <i>u</i>	0.24
Total - Unfiltered	µg/L	1.1	0.81	5.7	0.9	1.2	15.6
Methyl - Filtered	µg/L	0.00015	0.00032	0.00034	0.00008	0.00039	0.00042
Methyl - Unfiltered	µg/L	0.00075	0.00067	0.00287	0.00063	0.00095	0.00105
Total - Particulate ^a	mg/kg	73.3	62.3	173	64.3	74.2	1097
Methyl - Particulate ^a	mg/kg	0.04	0.027	0.077	0.039	0.036	0.045
Filtered Metals							
Arsenic	µg/L	2.4 <i>u</i>	2.4 <i>u</i>	2.4 <i>U</i>	3 <i>U</i>	4 <i>u</i>	2.5 <i>U</i>
Beryllium	µg/L	0.64 <i>U</i>	0.48 <i>U</i>	0.46 <i>U</i>	0.51 <i>U</i>	0.48 <i>U</i>	0.46 <i>U</i>
Cadmium	µg/L	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>
Chromium	µg/L	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>
Copper	µg/L	1.5 <i>u</i>	1.5 <i>u</i>	1.5 <i>u</i>	1.5 <i>u</i>	2.1	1.5 <i>u</i>
Iron	µg/L	21.5 <i>u</i>	27	86	21.5 <i>u</i>	149	96
Lead	µg/L	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>
Manganese	µg/L	874	265	267	871	509	309
Nickel	µg/L	6.4 <i>U</i>	4.3 <i>U</i>	3.5 <i>U</i>	6.6 <i>U</i>	4.5 <i>U</i>	3.6 <i>U</i>
Silver	µg/L	1.8 <i>u</i>	2 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>
Sodium	µg/L	1,510,000 <i>J</i>	156,000 <i>J</i>	146,000 <i>J</i>	1,580,000 <i>J</i>	429,000 <i>J</i>	195,000 <i>J</i>
Thallium	µg/L	5.9 <i>U</i>	4.5 <i>U</i>	5.2 <i>U</i>	7.9 <i>U</i>	8.2 <i>U</i>	5.5 <i>U</i>
Zinc	µg/L	32.6 <i>J</i>	42.4 <i>J</i>	23.8 <i>UJ</i>	31.1 <i>J</i>	27.7 <i>J**</i>	26 <i>UJ</i>
Unfiltered Metals							
Arsenic	µg/L	3.9 <i>U</i>	3.1 <i>U</i>	4.2 <i>U</i>	5.3 <i>U</i>	3.5 <i>U</i>	4.3 <i>U</i>
Beryllium	µg/L	0.19 <i>u</i>	0.31 <i>U</i>	0.37 <i>U</i>	0.21 <i>U</i>	0.32 <i>U</i>	0.25 <i>U</i>
Cadmium	µg/L	0.21 <i>u</i>	0.21 <i>u</i>	.48	0.21 <i>u</i>	0.21 <i>u</i>	0.44
Chromium	µg/L	4.9	1.2	9.6	4.8	2.1	11.2
Copper	µg/L	6.6	6.7	11.4	6.9	6	11.7
Iron	µg/L	644	1,850	2,310	708	1,560	2,180
Lead	µg/L	1 <i>u</i>	3.7	8.6	1 <i>u</i>	2.8	9.6
Manganese	µg/L	960	381	415	959	561	430
Nickel	µg/L	7.7	3.8 <i>U</i>	4.9 <i>U</i>	8.6	5.2 <i>U</i>	5.3 <i>U</i>
Silver	µg/L	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>
Sodium	µg/L	1,330,000 <i>J</i>	138,000 <i>J</i>	144,000 <i>J</i>	1,350,000 <i>J</i>	319,000 <i>J</i>	191,000 <i>J</i>
Thallium	µg/L	5.4 <i>U</i>	4.4 <i>U</i>	5.7 <i>U</i>	7 <i>U</i>	6.5 <i>U</i>	4 <i>U</i>
Zinc	µg/L	42.7 <i>J</i>	31.7 <i>J</i>	61.7 <i>J</i>	47.3 <i>J</i>	38.7 <i>J</i>	66.6 <i>J</i>
Other Parameters							
Total suspended solids	mg/L	15.	13.	33.	14.	16.	14.

TABLE 4-8. (cont.)

		Sample Location and Date of Sample Collection					
		SW-03	SW-03	SW-03	SW-04	SW-04	SW-04
		SW0004	SW0010	SW0014	SW0018	SW0020	SW0021
		10/31/97	10/31/97	10/31/97	11/12/97	11/12/97	11/12/97
Analyte	Units	HIGH TIDE	MID TIDE	LOW TIDE	HIGH TIDE	MID TIDE	LOW TIDE
Mercury							
Total - Filtered	µg/L	0.2 <i>u</i>	0.2 <i>u</i>	0.2	0.2 <i>u</i>	0.2 <i>u</i>	0.2 <i>u</i>
Total - Unfiltered	µg/L	0.78	0.74	1.3	1	0.88	0.2 <i>u</i>
Methyl - Filtered	µg/L	0.00047	0.00018	0.00026	0.00028	0.00029	0.00026
Methyl - Unfiltered	µg/L	0.00069	0.00058	0.0013	0.00099	0.00088	0.00282
Total - Particulate ^a	mg/kg	60	67.3	68.8	100	68	ND
Methyl - Particulate ^a	mg/kg	0.0169	0.036	0.065	0.071	0.059	0.0582
Filtered Metals							
Arsenic	µg/L	2.4 <i>u</i>	2.5 <i>U</i>	2.4 <i>u</i>	2.4 <i>u</i>	2.4 <i>u</i>	2.4 <i>u</i>
Beryllium	µg/L	0.31 <i>U</i>	0.55 <i>U</i>	0.46 <i>U</i>	0.19 <i>u</i>	0.19 <i>u</i>	0.19 <i>u</i>
Cadmium	µg/L	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>
Chromium	µg/L	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>
Copper	µg/L	6	1.5 <i>u</i>	4.5	1.5 <i>u</i>	1.5 <i>u</i>	2.7
Iron	µg/L	113	34	317	109 <i>U</i>	81.1 <i>U</i>	122
Lead	µg/L	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>
Manganese	µg/L	922	940	320	595	519	15
Nickel	µg/L	6.8 <i>U</i>	6.6 <i>U</i>	3.5 <i>U</i>	6.3	5.5	3.5
Silver	µg/L	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>
Sodium	µg/L	1,250,000 <i>J</i>	1,340,000 <i>J</i>	208,000 <i>J</i>	586,000	645,000	118,000
Thallium	µg/L	5 <i>U</i>	5.3 <i>U</i>	3.8 <i>u</i>	3.8 <i>u</i>	3.8 <i>u</i>	3.8 <i>u</i>
Zinc	µg/L	49.3 <i>J</i>	35.2 <i>J</i>	23.9 <i>UJ</i>	35.6 <i>J</i>	32.5 <i>J</i>	32.3
Unfiltered Metals							
Arsenic	µg/L	5.9 <i>U</i>	3.2 <i>U</i>	3.3 <i>U</i>	2.9	2.4 <i>u</i>	3.4
Beryllium	µg/L	0.19 <i>u</i>	0.19 <i>u</i>	0.26 <i>U</i>	0.19 <i>u</i>	0.19 <i>u</i>	0.25 <i>U</i>
Cadmium	µg/L	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.47 <i>u</i>
Chromium	µg/L	4.4	2.8	1.4	4.4	3.8	14.6
Copper	µg/L	5.5	5.1	5.6	7.1	6.8	14.5
Iron	µg/L	591	530	1,700	992	864	2,610
Lead	µg/L	1 <i>u</i>	1 <i>u</i>	3.2	3.9	2.2	8.1
Manganese	µg/L	1,010	981	424	612	536	425
Nickel	µg/L	7.7 <i>U</i>	8.6	4.2 <i>u</i>	6.9	6.5	5.8
Silver	µg/L	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>
Sodium	µg/L	1,020,000 <i>J</i>	1,140,000 <i>J</i>	190,000 <i>J</i>	579,000	635,000	117,000
Thallium	µg/L	8.6 <i>U</i>	7.4 <i>U</i>	5.1 <i>U</i>	6.7	3.8 <i>u</i>	3.8 <i>u</i>
Zinc	µg/L	46.6 <i>J</i>	43.6 <i>J</i>	32.9 <i>J</i>	50.1 <i>J</i>	50.4 <i>J</i>	88.8 <i>J</i>
Other Parameters							
Total suspended solids	mg/L	13.	11.	16.	10.	10.	44.

TABLE 4-8. (cont.)

Analyte	Units	Sample Location and Date of Sample Collection				
		SW-05	SW-06	SW-07	SW-08	SW-09
		SW0019 11/12/97	SW0006 10/31/97	SW0005 10/31/97	SW0001 10/31/97	SW0002 10/31/97
Mercury						
Total - Filtered	µg/L	0.2 <i>u</i>	0.2 <i>u</i>	0.2 <i>u</i>	0.2 <i>u</i>	0.2 <i>u</i>
Total - Unfiltered	µg/L	8.4	1.2	0.88	17.6	5.8
Methyl - Filtered	µg/L	0.00027	0.0002	0.00019	0.00085	0.00098
Methyl - Unfiltered	µg/L	0.00464	0.00081	0.00061	0.00218	0.00233
Total - Particulate ^a	mg/kg	100	92.3	88	2933	967
Methyl - Particulate ^a	mg/kg	0.0520	0.0469	0.0420	0.2217	0.225
Filtered Metals						
Arsenic	µg/L	2.4 <i>u</i>	2.4 <i>u</i>	2.4 <i>u</i>	2.7 <i>U</i>	2.4 <i>u</i>
Beryllium	µg/L	0.19 <i>u</i>	0.44 <i>U</i>	0.32 <i>U</i>	0.34 <i>U</i>	0.34 <i>U</i>
Cadmium	µg/L	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>
Chromium	µg/L	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>	1.2 <i>u</i>
Copper	µg/L	1.5 <i>u</i>	1.5 <i>u</i>	1.5 <i>u</i>	1.5 <i>u</i>	3.1
Iron	µg/L	124 <i>U</i>	21.5 <i>u</i>	21.5 <i>u</i>	130	690
Lead	µg/L	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>	1 <i>u</i>	4.7
Manganese	µg/L	681	948	910	351	373
Nickel	µg/L	7.8	6.7 <i>U</i>	6.4 <i>U</i>	3.6 <i>U</i>	4.2 <i>U</i>
Silver	µg/L	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>
Sodium	µg/L	290,000	1,220,000 <i>J</i>	1,140,000 <i>J</i>	550,000 <i>J</i>	549,000 <i>J</i>
Thallium	µg/L	5.3	6.3 <i>U</i>	5.1 <i>U</i>	4.2 <i>U</i>	5.9 <i>U</i>
Zinc	µg/L	531 <i>J</i>	55 <i>J</i>	37.9 <i>J</i>	53.2 <i>J</i>	76 <i>J</i>
Unfiltered Metals						
Arsenic	µg/L	14.2	5 <i>U</i>	2.6 <i>U</i>	2.4 <i>u</i>	3 <i>U</i>
Beryllium	µg/L	0.4 <i>U</i>	0.24 <i>U</i>	0.23 <i>U</i>	0.19 <i>U</i>	0.19 <i>u</i>
Cadmium	µg/L	8.2	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>	0.21 <i>u</i>
Chromium	µg/L	145	4.2	2.6	1.2 <i>u</i>	1.2 <i>u</i>
Copper	µg/L	104	11.1	6.3	3.2	2.4
Iron	µg/L	13,400	675	689	785	653
Lead	µg/L	119	1.2	1 <i>u</i>	4.2	2
Manganese	µg/L	1,960	1,020	916	368	365
Nickel	µg/L	27.9	7.9	6.9 <i>U</i>	4.4 <i>U</i>	4 <i>U</i>
Silver	µg/L	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>	1.8 <i>u</i>
Sodium	µg/L	295,000	1,140,000 <i>J</i>	929,000 <i>J</i>	396,000 <i>J</i>	438,000 <i>J</i>
Thallium	µg/L	9.5	9.9 <i>U</i>	6 <i>U</i>	6.4 <i>U</i>	6 <i>U</i>
Zinc	µg/L	5,680 <i>J</i>	71.9 <i>J</i>	56.3 <i>J</i>	43.6 <i>J</i>	35.9 <i>J</i>
Other Parameters						
Total suspended solids	mg/L	84.	13.	10.	6.	6.

Medium-specific SoPCs are highlighted

u = The compound was analyzed for but not detected*J* = Estimated

* Average value of field duplicates

** Single value reported only; duplicate was not detected

^a Particulate concentrations calculated by subtracting filtered values from unfiltered values and dividing that value by the TSS value

TABLE 4-9. SUMMARY OF SoPCs IN SEDIMENT

Analyte	Units (dry wt.)	Sample Location and Date of Sample Collection								
		SD-01	SD-02	SD-03	SD-04	SD-05	SD-06	SD-07	SD-08*	SD-09
		SD0003	SD0009	SD0008	SD0010	SD0001	SD0002	SD0007	SD0004/5	SD0006
		11/05/97	11/11/97	11/06/97	11/12/97	10/30/97	10/30/97	11/05/97	11/05/97	11/05/97
Mercury										
Total (0-15 cm)	mg/kg	33.8	69.6	70	0.16 <i>u</i>	59.2	67.3	69.6	1,290	1,280
Total (0-2 cm)	mg/kg	31.3	11,100	223	0.89	57.6	97.8	57.2	1,180	856
Methyl	mg/kg	0.0098	0.00975	0.008	0.00038	0.0119	0.012	0.02	0.126	0.0982
Metals										
Arsenic	mg/kg	6.7 <i>J</i>	7.5	9.1	6.6	16.8	21.3	24.6	3.6 <i>J</i>	8.8
Beryllium	mg/kg	0.38 <i>U</i>	0.3 <i>U</i>	0.38 <i>U</i>	0.55 <i>U</i>	0.65	0.77	0.69	0.56 <i>U</i>	0.83
Cadmium	mg/kg	6.8 <i>J</i>	13.8	9.3	0.07 <i>u</i>	12.1 <i>J</i>	13 <i>J</i>	17.1	0.89 <i>J</i>	1.6
Chromium	mg/kg	265 <i>J</i>	169	234	18	294 <i>J</i>	474 <i>J</i>	930	55.4 <i>J</i>	65.6
Copper	mg/kg	145 <i>J</i>	110	161	11.1	190 <i>J</i>	226 <i>J</i>	287	93.7 <i>J</i>	136
Iron	mg/kg	10,100 <i>J</i>	8,210	14,500	18,800	21,800	25,400	23,700	8,410 <i>J</i>	18,100
Lead	mg/kg	176 <i>J</i>	150	159	20.5	232	177	214	188 <i>J</i>	469
Manganese	mg/kg	128 <i>J</i>	97.3	150	189	415 <i>J</i>	521 <i>J</i>	537	85.3 <i>J</i>	179
Nickel	mg/kg	26.1	25	31.2	14.8	37.8 <i>J</i>	42.7 <i>J</i>	66.4	14.3	28.1
Silver	mg/kg	3.2	1.4	3.6	0.58 <i>u</i>	2.3 <i>J</i>	3.8 <i>J</i>	4.8	1.3 **	2.4
Sodium	mg/kg	490	322 <i>u</i>	1,000	1,030	1,040	2,810	2,750	711 <i>u</i>	1,130 <i>u</i>
Thallium	mg/kg	1.3 <i>u</i>	3.3	1.7 <i>u</i>	1.2 <i>u</i>	2.6 <i>u</i>	3.4 <i>u</i>	3.4 <i>u</i>	2.2 <i>u</i>	3.6 <i>u</i>
Zinc	mg/kg	709 <i>J</i>	602	792	56.1	7,300	4,640	2,640	556 <i>J</i>	844
Semivolatile Organic Compounds										
Anthracene	μ g/kg	16,000 <i>u</i>	450	250	520 <i>u</i>	960	1,400 <i>u</i>	1,500 <i>u</i>	250	350
Benz[a]anthracene	μ g/kg	16,000 <i>u</i>	1,200	1,300	520 <i>u</i>	1,800	450	370	880	1,700
Benzo[a]pyrene	μ g/kg	16,000 <i>u</i>	1,200	1,400	520 <i>u</i>	1,600	580	450	770	1,600
Benzo[b]fluoranthene	μ g/kg	16,000 <i>u</i>	1,500	1,800	520 <i>u</i>	2,200	920	620	920	1,800
Benzo[ghi]perylene	μ g/kg	16,000 <i>u</i>	720	730	520 <i>u</i>	730	400	400	580	1,200
Benzo[k]fluoranthene	μ g/kg	16,000 <i>u</i>	410	640	520 <i>u</i>	690	170	190	340	660
Bis[2-ethylhexyl]phthalate	μ g/kg	1,600	1,400	5,000	320	1,700	9,800	2,700	970 <i>U</i>	1,500 <i>U</i>
Chrysene	μ g/kg	16,000 <i>u</i>	1,600	1,500	520 <i>u</i>	1,800	610	460	880	1,600
Dibenz[a,h]anthracene	μ g/kg	16,000 <i>u</i>	190	220	520 <i>u</i>	250	1,400 <i>u</i>	1,500 <i>u</i>	170	320
Fluoranthene	μ g/kg	2,100	3,200	3,000 <i>J</i>	520 <i>u</i>	4,000	1,000	750 <i>J</i>	1,700 <i>J</i>	2,800 <i>J</i>
Fluorene	μ g/kg	16,000 <i>u</i>	440 <i>u</i>	100	520 <i>u</i>	560	1,400 <i>u</i>	1,500 <i>u</i>	114	170
Indeno[1,2,3-cd]pyrene	μ g/kg	16,000 <i>u</i>	710	800	520 <i>u</i>	850	350	380	600	1,200
Phenanthrene	μ g/kg	16,000 <i>u</i>	720	1,200	520 <i>u</i>	4,200	440	1,500 <i>u</i>	1,200	1,800
Pyrene	μ g/kg	1,900	2,400	2,100	520 <i>u</i>	3,100	910	750	1,610	2,900
PCBs										
Aroclor® 1248	μ g/kg	3,100	33 <i>u</i>	4,500	33 <i>u</i>	1,400	1,800	4,700	240	190
Aroclor® 1260	μ g/kg	290 <i>u</i>	33 <i>u</i>	320	33 <i>u</i>	110 <i>u</i>	140 <i>u</i>	430	490	260

Medium-specific SoPCs are highlighted

u = Compound was analyzed for but not detected*J* = Estimated

* Average value of field duplicates

** Single value reported only; duplicate was not detected

TABLE 5-1. SUMMARY OF GROUNDWATER CONVENTIONAL ANALYTES AND FIELD PARAMETERS

Analyte	Units	Sample Location and Date of Sample Collection						
		MW-1	MW-2	MW-3	MW-4	MW-5	MW-6*	MW-7
		GW0001 11/10/97	GW0005 11/11/97	GW0007 11/12/97	GW0013 11/25/97	GW0002 11/10/97	GW0003/4 11/11/97	GW0008 11/13/97
Conventional Analytes								
Biochemical oxygen demand	mg/L	36	30	60 <i>u</i>	2 <i>u</i>	42	2 <i>u</i>	60 <i>u</i>
Carbonate alkalinity	mg/L	1,100	950	1,100	1,000	1,400	590	470
Chemical oxygen demand	mg/L	44.0	140	130	83.0	48.0	45.0	47.0
Orthophosphate-phosphorus	mg/L	0.19	0.05 <i>u</i>	0.14	0.74	0.31	0.05 <i>u</i>	0.05 <i>u</i>
Petroleum hydrocarbons	mg/L	0.50 <i>u</i>	3.60	0.50 <i>u</i>	0.50 <i>u</i>	0.50	0.50 <i>u</i>	0.50 <i>u</i>
Sulfate	mg/L	5 <i>u</i>	37	730	5 <i>u</i>	5 <i>u</i>	52	30
Total chloride	mg/L	57	60	50	100	42	850	72
Total dissolved solids	mg/L	98	950	740	1,000	700	1,700	500
Field Parameters								
Color		Clear	Clear	Clear	Clear	Clear	Clear	Clear
Conductivity	mS/c	1,440	1,132	2,104	1,586	1,790	2,544	737
Dissolved oxygen	mg/L	0.52	0.43	0.31	0.30	0.11	1.25	0.27
Oxidation-reduction potential	mV	-135.7	-31.8	-72.5	-75.6	-48.0	-28.6	-69.1
pH		6.52	6.65	6.45	6.39	6.52	6.49	6.81
Specific conductance	µS/cm	1.69	1,399	2,505	1,864	2,204	3,270	965
Temperature	°C	17.1	15.1	16.6	17.2	15.2	13.4	12.6
Turbidity	NTU	577	1,365	5	924	10	22	12

TABLE 5-1. (cont.)

		Sample Location and Date of Sample Collection				
		MW-8	MW-9	MW-10	MW-11	MW-12
		GW0011	GW0012	GW0010	GW0009	GW0006
Analyte	Units	11/17/97	11/17/97	11/13/97	11/13/97	11/12/97
Other Parameters						
Biochemical oxygen demand	mg/L	12	3 <i>u</i>	5	100	60 <i>u</i>
Carbonate alkalinity	mg/L	400	140	400	270	470
Chemical oxygen demand	mg/L	50.0	18.0 <i>u</i>	28.0	130	36.0
Orthophosphate-phosphorus	mg/L	0.08	0.05 <i>u</i>	0.05 <i>u</i>	0.20	0.05 <i>u</i>
Petroleum hydrocarbons	mg/L	0.50 <i>u</i>	0.50 <i>u</i>	0.50 <i>u</i>	0.50 <i>u</i>	0.50 <i>u</i>
Sulfate	mg/L	42	40 <i>u</i>	13	8	260
Total chloride	mg/L	250	75 <i>u</i>	51	85	140
Total dissolved solids	mg/L	800	350 <i>u</i>	470	500	690
Field Parameters						
Color		Clear	Clear	Clear	Clear	Clear-light yellow
Conductivity	mS/c	1,008	390	624	620	1,092
Dissolved oxygen	mg/L	0.41	1.13	0.20	0.33	-0.19
Oxidation-reduction potential	mV	-66.6	-17.0	41.5	-68.7	-138.4
pH		6.56	7.00	6.91	6.19	6.34
Specific conductance	µS/cm	1,328	500	726	745	1,396
Temperature	°C	12.4	13.5	17.7	16.1	13.5
Turbidity	NTU	67	13	10	4	13

Notes: Field parameters are the average of values measured immediately before and after sampling. Complete data is included in Appendix E.

u - indicates that the compound was analyzed for but not detected (laboratory qualifier)

U - indicates that the compound was analyzed for but not detected (quality assurance and quality control review qualifier)

J - indicates an estimated concentration

* - indicates average value of field duplicates